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BOTANICAL GAZETTE

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UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS. XVIII.

JOHN DONNELL SMITH.

CLEOME PILOSA Benth., var. **Costaricensis** Donnell Smith.—Folia majora longius petiolata 5–9-secta. Flores rosei. Pedicelli cum sepalis glandulosi gynophoro 3-plo longiores.

Cartago, Costa Rica, alt. 4250 ft., Nov. 1887, *Cooper*, no. 5709 Pl. Guat. etc., qu. ed. Donn. Sm.; Oct. 1894, *Biolley*, no. 8996 herb. nat. C. R.—Old fields near S. José, C. R., Nov. 1889, *Tonduz*, no. 1450 herb. nat. C. R.

Xylosma oligandrum Donnell Smith.—Inerme glabrum. Folia membrancea inter maxima penninervia oblongo-elliptica aut -obovata, apice acuminato, basi acuta, dentibus remotis exsertis. Flores fasciculati, pedicellis petiolos subaequantibus. Sepala 4 inter minima. Stamina circiter 10, glandulis 8 connatis. Ovarium ellipsoideum sepala bis superans, disco integro, stylo bifido, stigmatibus semilunatis.

A small tree (Biolley); branches glabrate, lenticellate. Leaves translucent, polished above, paler beneath, 5–6 × 2–2½ in.; nerves 6–8 to the side, long-ascending, prominent beneath; teeth glandular-mucronate; petioles very short. Pedicels 2–3 l. long, masculine flowers numerous, the feminine 5–8; bracts scarious, naked, cymbiform, minute. Sepals ovate, scarcely ½ l. long, pubescent within. Stamens glabrous, 1 l. long. Ovary smooth, placentae 2-ovulate. Berry by abortion 1–3-seeded.—By foliage similar to *X. intermedium* Griseb., but distinct by inflorescence and to be located with *X. Benthami* Griseb.

Borders of the river Surubres near San Matéo, Prov. Alajuela, Costa Rica, alt. 900 ft., July 1890, *Biolley*, no. 2652 herb. nat. C. R.

Stellaria Irazuensis Donnell Smith.— Caules humifusi glabri. Folia longe petiolata glabra ovata aut ovato-lanceolata, apice acuminato, basi leviter cordata, margine crispato-crenulato. Pedunculi terminales longissimi, ramis binis filiformibus recurvis, floribus tetrameris minimis in cymas bracteolatas confertis. Petala partita, segmentis lineari-spatulatis quam sepala sesquilongioribus. Ovarium globosum digynum tetraspermum.

Stems stramineous, branching, apparently 2–3 ft. long. Leaves ½–1 in. × 4–8 l., epunctate, bordered by an intramarginal nerve; petioles pubescent, 5–10 l. long. Peduncles 4–8 in. long, branches 3–4 in. long, branchlets ½–1 in. long; bracts foliaceous, subsessile; cymes glandulose-pubescent, several times dichotomous; axes 1–2 l. long; bracteoles glabrous, ½–1 l. long. Sepals 4, oblong-elliptical, obtuse, ¾ l. long, smooth and shining, 1-nerved. Petals 4, parted to near the base, a little longer than the 4 stamens. Ovary ½ l. high, equaling the uncinate styles, 4-valvate. Seeds reniform, red, punctulate. — Remarkable among American species by the 4-merous flowers, and by its other characters nearest to *S. micrantha* Spruce (no. 6023 *Spruce!* no. 47 *Fendler!*).

Oak-clearings, slope of Volcán Irazú, Prov. Cartago, alt. 6000 ft., July 1891, *Tonduz*, no. 4292 herb. nat. C. R.

Saurauia Costaricensis Donnell Smith.—Ramuli petioli costae paniculae calyces simul cano-pubescentes et ferrugineo-setosi. Folia obovato-oblonga aut -lanceolata acuminata ad basin acuta aut obtusa supra sparsim strigillosa subtus molliter et in costa nervisque densius pubescentia, margine inaequaliter mucronato. Paniculae longe pedunculatae amplae alternatim laxeque ramosae. Sepala intus subglabra petalis discretis glabris dimidio breviora. Styli ovario bis longiores. Bacca cano-lanuginosa.

A small tree. Bristles of branchlets paleaceous, puberulous, tipped with a hair, usually copious and spreading, occasionally more sparing short and appressed. Leaves 9–13 × 3¾–5 in., scarcely rough to the touch, sometimes glabrescent beneath, petioles 1–2 in. long. Panicles axillary, shorter than their peduncles, occasionally nearly as long as the leaves; bracteoles linear, 3–8 l. long; flowers hermaphrodite. Sepals nearly equal, 2 l. long; setose on the back, the 2 exterior ones everywhere, the 1 intermediate on one half, the 2 interior in a line; the 3 exterior ovate, setulose or at least pubescent on face near the apex; the 2 interior orbicular, glabrous on face and margin. Petals 4 l. long, 2 l. broad, each end obtuse. Stamens biserial, about 32, intermixed hairs white, filaments 1 l. long; anthers linear, 1 l. long, affixed

near the middle, dehiscing by a slit. Ovary densely villous, styles 2 l. long. Berry globose, 4 l. in diam., enclosed by the accrescent calyx; seeds yellow, truncate-obpyramidal, ¼ l. long, deeply alveolate.—*S. scabrida* Hemsl., *S. strigillosa* Triana et Planch. and *S. Lehmannii* Hieron., with somewhat similar indument, differ from the above by scabrid leaves and glabrous ovary; *S. Veraguensis* Seem., related by its hirsute ovary, is distinct by tomentose sepals and petals.

Cartago, Costa Rica, alt. 4250 ft., Dec. 1887, *Cooper*, no. 5714 Pl. Guat. etc., qu. ed. Donn. Sm.—Rio Segundo, C. R., alt. 6000 ft., Jan. 1890, *Tonduz*, no. 1744 herb. nat. C. R.—San Márcos de Dota., C. R., alt. 3800 ft., Mch. 1893, *Tonduz*, no. 7685 herb. nat. C. R.—Alajuelita, Prov. S. José, C. R., alt. 3300 ft., Mch. 1894, *Donn. Sm.* no. 4745 Pl. Guat. etc., qu. ed. Donn. Sm.—Navarro, Prov. Cartago, C. R., alt. 3500 ft., *Donn. Sm.*, no. 4746 Pl. Guat., etc., qu. ed. Donn. Sm.—San José, C. R., alt. 3600 ft., Nov. 1894, *Pitt & Tond.*, no. 8959 herb. nat. C. R.

Saurauia Pittieri Donnell Smith.—Ramuli cum petiolis paniculisque ferruginei scabriusculi. Folia late oblongo-obovata, apice subobtuso, basi acuta, facie superiori tuberculis rubris scabrida, inferiori in costa nervis venis venulis canescente. Paniculae pedunculis longiores folia paene aequantes pyramidales, axibus alternis. Sepala parva petalis vix breviora utrinque canescentia tuberculis rubris extus punctata. Stamina pauca. Ovarium glabrum, stylis perbrevibus.

Arboreous. Younger parts rubescent, densely and minutely scabrid. Leaves 7½–10 × 3¾–5½ in., ending above in an obtuse and below in an acute angle; upper surface tubercular-punctate, otherwise glabrous; the lower besides the canescent reticulation sprinkled with a stellate pubesence; petioles ¾–1 in. long. Panicles axillary, 7–8 in. long, lowest branches 3–3½ in. long; bracteoles linear, 1–4 l. long; flowers hermaphrodite, 5 l. in diam. Sepals oval, 2 l. long; the exterior 2 tuberculose on the back, the intermediate 1 on a half of the back, the interior 2 in a dorsal line. Petals slightly connate, broadly oblong, glabrous. Stamens biserial, 20–24; filaments 1 l. long, at base sparingly barbate with white hairs; anthers somewhat shorter, oblong, affixed near the middle, dehiscing by a slit. Ovary ovate-globose, 5-sulçate, styles ¼ l. long. Berries not seen.—Easily recognized by the leaves not at all acuminate and the tuberculated calyxes.

Forests of La Palma, Pacific slope, Costa Rica, alt. 4800 ft., Sept. 1896, *Pittier*, no. 10163 herb. nat. C. R.

Pavonia oxyphyllaria Donnell Smith.—Rami petioli pedunculi simul pube stellata incana et pilis simplicibus patentibus

ferrugineis vestiti. Folia brevissime petiolata oblongo-elliptica acuminata ad basin angustam inaequalem 3-nerviam rotunda utrinque pilosa pellucida leviter lateque dentata. Flores pedunculati in axillis supremis solitarii albi. Bracteolae involucrantes 11–12 lineares teretes ciliatae calycem 4-plo superantes petala aequantes tubo stamineo bis longiores. Carpella bimucronata.

Fruticose, a foot and a half high. Leaves 3¼–4¼ × 1–1¾ in., the midrib and 6–8 lateral nerves ferruginous beneath, petioles 1–2 l. long and equaling the subulate stipules. Peduncle 6–7 l. long, recurved. Bracteoles of involucre distinct, half an inch long, beset everywhere with patent ferruginous hairs a line long. Calyx campanulate, 1½ l. high, velutinous outside, 5-nerved, veinless; teeth deltoid, ½ l. long, ciliate. Petals obliquely obovate, twice longer than broad, on each side pubescent, apex retuse. Staminal tube dentate, above the middle bearing subsessile anthers. Ovary depressed-globose, style exceeding by 1 line the staminal tube. Capsule not present in the specimens collected.—Apparently nearest to *P. Bahiensis* Guercke.

Borders of the river Verde, Hacienda de La Emilia, Llanos de S. Clara, Costa Rica, alt. 750 feet., May 1896, *Donn. Sm.*, no. 6449 Pl. Guat., etc., qu. ed. Donn. Sm.

Malvaviscus Palmanus Pittier et Donn. Sm.—Folia longe petiolata obovato-elliptica bis longiora quam latiora abrupte acuminata ad basin 3-nerviam acuta integra ad apicem versus denticulata supra pube adspersa subtus praeter nervos glabrescentia. Pedunculi ex axillis foliorum terminalium prodeuntes brevissimi. Bracteolae involucrantes 9 subulato-lineares calycem paene aequantes petalis 3-plo breviores.

Fruticose; branches, petioles and peduncles velvety; pubescence stellate. Leaves 6–7 in. long, pellucid-punctate, basal nerves stout and ascending to the upper third of the leaf; petioles 1½–2½ in. long; stipules triangular-linear, 5–6 l. long. Peduncles 3–4 at tips of stem and branches, half an inch long, bracteating leaves crowded and reduced in size. Bracteoles of involucre pubescent, 6 l. long, subterete. Calyx pubescent on outside, pellucid-punctate, 7 l. high, 10-nerved, triangular teeth 2 l. long. Petals scarlet, obovate-spatulate, 17 × 6–7 l., puberulous outside, apex retuse, basal auricle ferruginous-barbate. Staminal tube not yet exsert in the specimens seen, bearing at its apex deflexed filaments 1 l. long and twice longer than the elliptical anthers, subulate teeth 1 l. long. Ovary depressed-globose, lepidote; the style exceeding staminal tube by puberulous branches 1 l. long. Berry unknown.—Differing from all congeners by the leaves. The locality, La Palma, is situated on

the divide between the Atlantic and the Pacific slopes and is subject to a high rate of rainfall without distinction of seasons. It is remarkable for the number of new or rare plants that have been found in its neighborhood.

Forests of La Palma, Prov. S. José, Costa Rica, alt. 5100 ft., July 1895, *Tonduz*, no. 9712 herb. nat. C. R.

Quararibea platyphylla Pittier et Donn. Sm.—Folia pedalia ovalia altero tanto longiora quam latiora cuspidata ad basin rotunda inaequilatera omnino glabra, petiolis geniculatis. Flores singuli breviter pedunculati. Tubus stamineus calyce 4-plo petalis bis longior in septima parte superiori sparsim antheriferus, tubi lobis staminodia gerentibus.

Branchlets glabrous excepting the lepidote leaf-buds. Leaves coriaceous, basal nerves 3, the lateral ones 5–7 to the side and with naked axils; petioles stout, glabrous, verrucose, half an inch long, geniculate above the middle at a right angle. Flowers axillary. Calyx 3-bracteolate, twice longer than peduncle, on outside minutely lepidote but otherwise glabrous, sericeous inside, tubulous-obconic, in anthesis 6 × 3 l., breaking irregularly into 4–5 lobes. Petals cuneate-linear, 11 l. long, pubescent on outside. Staminal tube glabrous, 22–24 l. long; lobes oblong, 1 l., apiculate, punctate at apex with red staminodes; anthers 1-celled, about 28, glomerate above, subverticillate below, nearly adnate, occasionally geminate, reniform, ¾ l. long. Ovary semi-inferior, conical, style shortly exsert and pubescent at apex, superior lobe of stigma produced. Fruit not seen.—*Q. turbinata* Poir, similar in habit, differs chiefly by stamens and pistil little exceeding petals, anthers otherwise arranged.

Forests of the river Naranjo, Comarca de Puntarenas, Costa Rica, alt. 600 ft., Mch. 1893, *Tonduz*, no. 7579 herb. nat. C. R.

Buettneria macrocarpa Donnell Smith.—Frutex erectus inermis, ramulis teretibus petiolis inflorescentia minute stellato-pubescentibus. Folia longe petiolata glabrescentia integerrima acuminato-ovata aut ovato-lanceolata ad basin rotunda 5-nervia. Pedunculi axillares solitarii, cymis fructiferis petiolos aequantibus. Capsulae inter maximas generis spinis longis rigidis et aculeis brevibus dense armatae.

Leaves 4–6 × 2–3 in., midrib beneath pubescent and marked near the base with a linear gland, the interior basal nerves ascending nearly to apex of leaf, the lateral nerves 2–3 to the side, transverse veins conspicuous beneath, petioles 2–3 in. long. Peduncles in fruit 3–6 l. long, cymes 3–4 times dichotomous, pedicels 1½–3 l. long. Capsules depressed-globose,

8 × 10 l.; spines pubescent, pungent, 3–4 l. long. Nutlets crustaceous, dehiscing loculicidally to beyond the middle; seeds oval, 4 × 2½ l., glabrous, fuscous, cotyledons spirally convolute. Flowers not present in the specimens. — Related to *B. Carthagenensis* Jacq., which differs chiefly by the prickles and small capsule.

Borders of the river Ceibo near Buenos Ayres, Comarca de Puntarenas, Costa Rica, alt. 600 ft., Jan. 1892, *Tonduz*, no. 6689 herb. nat. C R.

HELIOCARPUS POLYANDRUS Watson, var. **nodiflorus** Donnell Smith.— Arbor, foliis subtus velutinis, inflorescentiae ramis sarmentosis subflexuosis, nodis floribundis, inferioribus saepe foliatis, floribus dimidio majoribus.

Rio Pinula, Depart. Santa Rosa, Guat., alt. 4000 ft., Dec. 1892, *Heyde & Lux*, no. 4329 Pl. Guat., etc., qu. ed. Donn. Sm. sub. *H. Americanus* L., *forma floribus masculis pleiostemonis*.— Rio Torres, S. Francisco de Guadalupe, Prov. S. José, Costa Rica, alt. 3400 ft., Dec. 1893, *Tonduz*, no. 8453 herb. nat. C. R.

Erythroxylum Costaricense Donnell Smith. (§ ENGYANTHAE METRIOSEPALAE Peyritsch in Mart Fl. Bras.)— Folia digitalia oblongo- aut obovato-elliptica altero tanto longiora quam latiora acutissime acuminata in petiolum brevem cuneatim angustata pellucido-punctulata subtus glaucescentia, stipulis sicut ramentae striatis elongato-triangularibus petiolos superantibus. Flores pluri-glomerati breviter pedicellati. Sepala petalis dimidio breviora urceolum stamineum aequantia a filamentis 2–3-plo superata.

Branchlets terete, covered towards their tips with scales that are bifarious, imbricating, triangular-linear, half an inch long, aristulate. Leaves chartaceous, 3½–4 × 1½–2 in., terminating in a mucro, areoles and lines of prefoliation obsolete, petioles 2–3 l. long, stipules caducous. Glomerules 10–15-flowered; pedicels 1–1½ l. long, incrassate and pentagonal upwards; bracteoles scarious, striate, triangular, acute, subequaling pedicels. Sepals orbicular, ½ l. in diam., mucronate. Petals oblong, ligule a half shorter than the blade, lateral lobes conduplicate and crenulate, the commissural one most minute. Staminal tube in anthesis ½ l. high, slightly crenate, the longer filaments 1½ l. long. Ovary ellipsoid, ½ l. long, a little exceeding the 3 styles which are distinct from the base, stigmas capitate. Mature drupes not seen.—To be grouped with *E. amplum* Benth. and *E. laurinum* Triana et Planch.

Forests of Santo Domingo, Golfo Dulce, Costa Rica, little above sea level, Mch. 1896, *Tonduz*, no. 10092 herb. nat. C. R.

Oxalis vulcanicola Donnell Smith.—Trifoliastrum totum praeter flores ferrugineo-pilosum, radice fibrosa, caulibus decumbentibus ramosis, stipulis ad apicem liberis. Foliola obovata, lateralia paulo minora et ad basin inaequalia, apice deltoideo-emarginato. Pedunculi folia superantes multiflori, pedicellis gracilibus. Sepala glabra lineari-lanceolata petalis dimidio breviora staminibus majoribus triente pistillo dimidio longiora. Filamenta glabra. Capsula oblonga sepala aequans, loculis oligospermis.

Herbaceous, 1–2 ft. long, towards extremities sericeous. Stipules linear, adnate except the triangular apex. Petioles ¾–1½ in. long. Leaflets subsessile, pilose especially beneath, 7–11 × 5–7 l., the terminal one cuneate at base, the lateral rounded below on the outer side. Peduncles axillary, single, filiform, 2–4 in. long, cymes 6–12-flowered; pedicels subaggregated, 4–6 l. long; bracteoles linear, 1–2 l. long. Sepals 3–3½ l. long, the alternate ones narrower and linear. Petals yellow, streaked with violet, 6–7 l. long. Pistil oblong; styles very short, occasionally filiform. Capsule 3–3½ l. long; seeds 1–4 to the cell, oval, ½ l. long, rugose, red.—Nearly related to *O. pubescens* HBK., which differs by an erect habit, smaller flowers, broad sepals, barbate filaments.

Borders of a stream at Sitio Birris, Volcán Irazú, Costa Rica, alt. 8500 ft., Mch. 1888, *Pittier*, no. 164 herb. nat. C. R.—Valley of Los Arcángeles, Volcán Irazú, alt. 5700 ft., May 1888, *Pittier*, no. 70 herb. nat. C. R.—Southeastern flank of Volcán Poas, C. R., alt. 5700 ft., Jan. 1889, *Pittier*, no. 869 herb. nat. C. R.—Volcán Turrialba, C. R., alt. 7000 ft., *F. N.-Cox*, no. 4757 Pl. Guat., etc., qu. ed. Donn. Sm. sub *O. pilosissima* Turcz.

Impatiens Turrialbana Donnell Smith.—Glaberrima. Folia opposita longe petiolata oblongo-elliptica utrinque acuta supra medium remote serrata. Pedunculi solitarii filiformes biflori. Flores toti concolores purpurei. Sepala 3, lateralia orbiculari-ovata petalum anticum cucullatum aequantia, saccus aeque latus atque longus a petalis lateralibus paulo superatus, calcari brevi incurvo ad apicem inflato. Ovarium in unoquoque loculo bispermum.

A large herb; branches dichotomous, sulcate, leafy chiefly towards the end. Leaves 2½–3¼ in. × 10–14 l., apiculate with a mucro, attenuated into petioles 9–15 l. long, often entire, paler beneath. Peduncles 1–1¾ in long, pedicels ¾–1¼ in. long. Flowers minutely setulose-punctate. Anterior sepal 0, the lateral 4 l. long, obliquely subcordate at base, apiculate, colored,

many-nerved; saccate sepal 9 l. long and broad, spur 4 l. long. Anterior petal broadly oblong; the lateral oblong-elliptical, emarginate at apex, oval lobes 2 l. long. Filaments 3 l. long, anthers 1 l. long and broad. Capsule not seen.—Related by inflorescence and floral structure to the two New World species, but distinct from both by opposite leaves and large purple flowers.

Crossing of the river Birris on the road ascending Volcán Turrialba, Prov. Cartago, Costa Rica, alt. 7200 ft., May 1889, *Pittier*, no. 885 herb. nat. C. R. —Volcán Turrialba, alt. 7000 ft., Mch. 1894, *F. Nutter-Cox*, no. 4758 Pl. Guat., etc., qu. ed. Donn. Sm. sub. *I. fulva* Nutt.

Esenbeckia litoralis Donnell Smith. (§ HYMENOPETALAE Engl. in Mart. Fl. Bras.)—Ramuli dichotomi, novelli sicut petioli paniculaeque pubescentes. Foliola 3 membranacea supra fere glabra subtus praesertim ad nervos pubescentia obovata, apice rotundo aut breviter obtuseque cuspidato, basi cuneata, margine obsolete crenato, intermedium quam petiolus subteres multoties longius. Paniculae terminales trinae foliis breviores, ramis alternis brevissimis. Sepala et petala sicut bracteolae in dorso ciliata Ovarii tubercula parce minuteque verrucosa.

Branchlets spotted with lenticels, leafy towards their summit, the tip canosericeous. Petioles 5–9 l. long, semiterete towards their base. Leaflets sessile, minutely pellucid-punctate; the terminal one about 6 times longer than the petiole, 2½–4½ × 1¾–2½ in.; the lateral ¼ to ⅓ smaller, base unequal. Panicles furnished each one at base with a linear bract 1 l. long, racemiform, 1½–2 in. long, branches 2–3 l. long; bracteoles ovate, 1 l. long; flowers 5-merous, subglomerate. Sepals imbricate, semiorbicular, ½ l. high. Petals imbricate, oblong, 1½ l. long, obtuse, sparingly and minutely pellucid-punctate. Stamens equaling the petals, filaments dilated below, anthers cordate and lobed to the middle. Disk ¼ l. high, ¾ l. broad, 10-crenate. Ovary immersed; tubercles 5, minute, furnished with 3–5 yellow gland-like warts; cells biovulate; style subulate, ½ l. long. Capsule not seen.—*E. Acapulcensis* Rose is the most nearly related species; it differs by glabrous and long-petiolate leaves, ample panicles void of hairs, naked and closely punctate petals, ovary densely covered by erect warts. *E. Berlandieri* Baillon, likewise related, is distinct by spotted petals and the 4-locular ovary.

Dry prairies along the coast of the Bay of Salinas, Comarca de Puntarenas, Costa Rica, July 1890, *Pittier*, no. 3317 herb. nat. C. R.

Cormonema ovalifolium Donnell Smith. (*Colubrina spinosa* Donn. Sm. in Bot. Gaz. **23**: 4. 1897.)—Folia glabra subtus reticulata ovalia altero tanto longiora quam latiora breviter obtuseque

acuminata ad basin rotunda et juxta petiolum biglandularia. Pedunculi ad basin bracteosi pluri-fasciculati. Drupa globosa magna, epicarpio intus confluenti-granuloso, seminibus orbicularibus compressis erubescentibus punctatis, cotyledonibus laete prasinis.

Spines not present in the single specimen. Leaves subdistichous, 3½–5½ × 1¾–2½ in., both surfaces green, only the lower one reticulated; glands large, disk-shaped; petioles corrugated, canaliculate, 7 l. long. Peduncles and small ovate bracts rusty puberulous. Drupe 4½ l. in diam., thrice exceeding the cupule of calyx, dehiscing septicidally from the base and loculicidally from the apex; epicarp reddish, rugulose outside, within closely occupied by large yellow granules; nutlets crustaceous with hyaline sides; seeds with a glaucous bloom, 3 l. long and broad, convex on back, flat and scarcely angulate on face. Flowers not seen.— The two Central American species recently published by Dr. J. N. Rose in Contr. U. S. Nat. Herb. 3:315, differ from the above as follows: *C. Nelsoni* by smaller subrhomboid leaves reticulated on both surfaces, glands remote from the petiole, epicarp sparingly granulated, pale obovoid seed, white cotyledons: *C. Mexicana* (more nearly related) by elongated leaves narrowing from the middle downwards, few and naked peduncles, reticulated epicarp, dark obovoid seed. The remaining species, *C. spinosum* Reissek from Brazil, as described and figured seems distinct by lanceolate-elliptical leaves with pubescent nerves, short petioles, obovoid seeds with an angular face.

Forests along the river Zhorquin, Talamanca, Costa Rica, Mch. 1894, *Tonduz*, no. 8507 herb. nat. C. R.

No. 4569 herb. nat. C. R., likewise cited for *Colubrina spinosa*, is to be referred to *Cormonema Nelsoni* Rose.

RUBUS GUYANENSIS Focke, var. **vulcanicolus** Donnell Smith.— Folia pleraque quinata. Pedunculi parce aculeati.

Leaflets with parallel and close transverse veins, midrib aculeate beneath. Petals roseate, orbicular, 3 l. in diam., a little longer than the ovate-lanceolate sepals. Drupelets small, numerous, glabrous; receptacle linear, 3 l. long, glabrous.

Rancho del Achiote, S. W. flank of Volcán Poas, Costa Rica, alt. 6800 ft., Jan. 1889, *Pittier*, no. 806, herb. nat. C. R.—Rancho Flores, forests of Volcán Barba, Costa Rica. alt. 6200 ft., Feb. 1890, *Tonduz*, no. 2120 herb. nat. C. R.

Escallonia Poasana Donnell Smith.—Glabrescens. Ramuli alati sicut pedunculi glandulis stipitatis obsiti. Folia basi semiamplexicauli decurrenteque subsessilia obovato-cuneata obtusa

discoloria nervis et venis pellucidis supra impressa subtus fusco-reticulata, margine revoluto glanduli-crenulato. Flores terminales solitarii. Calycis depresso-hemispherici lobi inaequales oblongo-triangulares remoti, pars libera petalis oblongis vix dimidio brevior. Capsula paene libera a stylo superata.

Branchlets closely leafy. Leaves subcoriaceous, 10–12 × 4–6 l., under surface white and conspicuously reticulated, midrib beneath puberulous. Peduncles about 3 l. long. Tube of calyx about equaling the peduncle, at base turbinate and glandulose, suddenly dilated above and puberulous, 5 l. in diam.; lobes 1½–3 l. long, glandular-margined, sinuses 1 l. broad. Petals 5 l. long, 1½ l. broad; the spreading tip orbicular, scarcely broader than the claw, reticulated. Stamens 3½ l. long, anthers 1 l. long. Style bifid at apex, 3 l. long. Capsule bilocular, placentas 4.—*E. myrtilloides* L., the most closely related species, is distinguishable by its naked subangulate branchlets, twice to thrice smaller and simply venose leaves, and spathulate petals.

Borders of the upper lake of the Volcán Poas, Costa Rica, alt. 7700 ft., Aug. 1890, *Pittier*, no. 2971 herb. nat. C. R.

Psidium savannarum Donnell Smith. (§ALBO-TOMENTOSA Berg, in Mart Fl. Bras.)—Totum pallide ochraceo-tomentosum. Folia opposita et alterna sessilia obovata obtusa aut angulo lato acuta deorsum cuneata discoloria supra tomentosella subtus pannosa crebre nervia. Pedunculi solitarii uniflori. Alabastra parva obovata aperta supra ovarium haud constricta. Calycis lobi 5 triangulares. Petala inaequalia glabra. Ovarium 3-loculare.

Annotinous branches (the only ones present in the specimens) subterete. Leaves 18–25 × 10–12 l., membranaceous, elevated-pellucid-punctate above; costa flat above, prominent beneath; nerves prominent beneath, the lateral about 20 to the side and straight, the conjunctive distant from margin and slightly arching. Peduncles about 8 l. long, the lowest from axils of minute oblong-obovate leaves. Flower-buds 4 l. long. Calyx before anthesis dentate, afterwards slightly produced above ovary; lobes 1½ l. long, acute, cano-sericeous within like disk. The 3 larger petals 4 l. long, obovate, a little longer and twice broader than the others. Stamens 3 l. long, anthers shortly oblong. Ovary obconical, scarcely longer than calyx-lobes, shorter than the linear and persistent bracteoles; placentae bilamellate, distinct from axis; ovules about 8-serial. Berry not seen.— Related by some of its characteristics to *P. basanthus* Berg, which differs, however, by velutinous indument, leaves obsoletely nerved and all scattered, patelliform calyx with rounded teeth, and ciliate petals.

Savanna at Buenos Ayres, Comarca de Puntarenas, Costa Rica, alt. 800 ft., Febr. 1891, *Tonduz*, no. 4033 herb. nat. C. R.

Calyptranthes Tonduzii Donnell Smith.—Ramuli teretes et cymulae pubescentes. Folia oblongo-elliptica e medio utrinque acuminata, raro oblongo-obovata, glabra opaca crebre nervia supra lucida et pallescentia subtus obscura. Pedunculi axillares solitarii 3-flori foliis multo breviores, pedicellis brevissimis. Baccae maximae operculo conico saepe appendiculatae 1–18-spermae, seminibus nonnullis saepe imperfectis, testa ossea, cotyledonibus planis minimis.

Small tree with a spreading head (Tonduz), densely branched, fruiting profusely. Leaves twice or thrice exceeding internodes, 15–21×6–9 l., coriaceous, limbinerved, upper surface variegated with white and green, the lower impellucid-punctate, midrib pubescent above, nerves distinct on both sides, margin revolute; petioles very short, dark. Peduncles from nearly all nodes, 4–5 l. long; lateral pedicels deflexed, 1 l. long, the intermediate obsolete. Berries globose, yellow, glandular-punctate, 4–5 l. in diam., crowned with short tube of calyx; operculum persisting laterally, 1 l. high and broad, obtuse, glabrous; epicarp coriaceous; cells 1–3; seeds globose or variously compressed, occasionally superposed; radicle terete, strongly incurved; cotyledons oblong, ½ l. long, nearly free. No flowers present in the specimens. —Abnormal as to seed and approaching *Myrtus;* otherwise nearest to *C. rigida* Sw.

Banks of the river Virilla, Prov. S. José, Costa Rica, alt. 3400 ft., Dec. 1895, *Tonduz*, no. 9822 herb. nat. C. R.

Eugenia Guatemalensis Donnell Smith. (§ RACEMOSAE Berg in Mart. Fl. Bras.)—Folia discoloria supra glabra subtus incana lanceolato-elliptica utrinque acuminata. Pseudo-racemi axillares 1–2-ni, terminales 4-ni, foliis breviores pauciflori. Calycis usque ad discum partiti segmenta glanduli-tuberculosa, interiora concava exterioribus 3-plo majora petalis paulo minora. Ovarium obpyramidale biloculare multiovulatum.

Branches smooth, at tips cano-pubescent. Leaves 2¾–3½×1–1½ in., densely pubescent beneath, pellucid-punctate, limbinerved, lateral nerves of both surfaces distinct; petioles glabrous, 3 l. long. Racemes pubescent, at first shortly corymbose, rhachis at length elongate and 10–16 l. long, 5–9-flowered, pedicels opposite and 2–3 l. long, terminal flower subsessile in the fork, bracts minutely subulate. Flowers rubescent. Sepals rubri-punctate, strigillose-pubescent on both sides, the larger orbicular and 1¼–1½ l. long,

the smaller ovate. Petals orbicular, 1¼ l. long, glabrous, pellucid-punctate. Stamens 2 l. long, anthers globose. Ovary flavo-sericeous, 1¼ l. high, bracteoles minutely subulate, disk glabrous, ovules about 8 to the cell, style 2½–3 l. long. Mature berries not seen.

Forests of Santa Rosa, Depart. S. Rosa, Guatemala, alt. 5000 ft., July 1887, *von Türckheim*, no. 1318 Pl. Guat., etc., qu. ed. Donn. Sm.

Jussieua geminiflora Donnell Smith. (§ EUJUSSIAEA Micheli)—Fruticosa glabrescens. Folia subsessilia elongato-lanceolata ad basin acuminata. Flores singuli aut bini brevissime pedicellati tetrameri parvi. Calycis tubus in medio lineari-bibracteolatus lobos aequans petala orbiculari-ovata paulo superans. Discus leviter elevatus. Stylus crassus brevissimus. Capsula obovoideo-globosa.

Shrub 6–8 ft. high, branching freely, branchlets subterete, the younger ones pubescent. Leaves membranaceous, puberulous on midrib and nerves, otherwise smooth and shining on both surfaces, 3–4×¾–1 in., slenderly and acutely elongated, decurrent to the very short petiole. Pedicels most often geminate, puberulous, in anthesis ½ l. long, in fruit 2 l. long. Bracteoles 2 l. long, ¼ l. broad, free from the small subulate stipels. Calyx sparsely pilose; the tube tetragonal-obconic, 2 l. long; lobes triangular-lanceolate, 1 l. broad. Petals 1½–1¾×1¼ l. Disk pubescent, ½ l. high. Stamens a little exceeded by stigmas; anthers subsessile, torulose, ¾ l. long. Style ¼ l. long, ecostate. Capsule 5×3½ l., scarcely angulate; seeds oblong, ⅓ l. long, estriate, punctulate.—Nearly related to *J. latifolia* Benth., which differs chiefly by ovate leaves, solitary flowers, lanceolate bracteoles, petals broader than long, and very elevated disk.

Confluence of the rivers Puerto Viejo and Sarapiqui, Costa Rica, Jan. 1893, *Biolley*, no. 7379 herb. nat. C. R.—Swampy thickets, Atirro, Prov. Cartago, Costa Rica, alt. 1800 ft., Apr. 1896, *Donn. Sm.*, no. 6502 Pl. Guat., etc., qu. ed. Donn. Sm.

Passiflora Pittieri Mast. (§ ASTROPHEA)—Arbuscula ut videtur fere ecirrata; ramis angulatis sulcatis brevissime puberulis; petiolis 15 mill. superne sulcatis ad basin laminae glandulosis; stipulis petiolis dimidio brevioribus lineari-subulatis; foliis 9–10×4 cent. subcoriaceis glabris oblongis abrupte acuminatis; pedunculis axillaribus petiolis duplo longioribus supra medium articulatis; bracteis dissitis setaceis parvis; flore diamet. 6 cent., tubo glabro 12 mill. infundibuliformi; sepalis 40 mill. long. crassiusculis oblongo-obtusis exappendiculatis; petalis sepalis conformibus

iisque parum brevioribus tenuoribusque; corona fauciali pluriseriali filamentosa, filis extimis petaloideis dolabriformibus, petalis dimidio brevioribus, sequentibus approximatis brevioribus; corona media e medio tubi assurgente cylindrato-tubulata; gynandrophoro tenue angulat o glabro; filamentis angustis; ovario oblongo-truncato striato, fulvo-tomentoso, stylis cylindratis tomentosis ab angulis ovarii profisciscentibus eoque duplo longioribus crassiusculis; stigmatibus oblique capitatis.

An interesting species allied to some British Guianan forms and in some measure intermediate between section *Astrophea* and other sections.

Thickets of Santo Domingo, Golfo Dulce, Costa Rica, Mch. 1896, *Pittier*, no. 9894 herb. nat. C. R.

Passiflora pediculata Mast. (§ DECALOBA.)—Ramis gracilibus glabris, petiolis elongatis ad 6–7 cent. long. gracilibus eglandulosis vel versus basin glandulis 2 sessilibus onustis; stipulis caducis lineari-subulatis; laminis 5×9 cent. papyraceis glabris rotundatis basi cordatis 3-nerviis, antice fere ad medium trilobatis, lobis oblongis obtusiusculis late divergentibus, mediano longiore; pedunculis gracilibus petiolis parum brevioribus; bracteis approximatis caducis lineari-subulatis parvis; flore circa 3 cent. diam.; tubo glabro pateriformi; sepalis oblongis obtusis; petalis conformibus minoribus; corona fauciali e filis petaloideis uniseriatis transversim violaceo-fasciatis petalis parum brevioribus constante; corona media membranacea integra tubulata inflexa; corona infra mediana annulari crassa; ovario ellipsoideo glabro, stylis lineari-clavatis.—Florem unicum tantum examinavi.

Thicket on banks of the river Torres near San Francisco de Guadalupe, Prov. S. José, Costa Rica, alt. 3400 ft., Feb. 1893, *Tonduz*, no. 7250 herb. nat. C. R.

Carica dolichaula Donnell Smith.—Inermis. Folia digitatim 3–5-foliolata, foliolis longiuscule petiolulatis. Corollae tubus lobos multoties excedens. Filamenta breviter monadelphia, antheris magnis dimorphis, alternis prope medium affixis leviter bilobis, omnium connectivo supra articulationem bialato. Pistillum rudimentarium longissimum.

Tree 20 ft. high, branching, glabrous in all parts. Leaflets 3- or 4- or 5-nate, thin-membranaceous, glaucous beneath, oblong- or obovate-elliptical, abruptly acuminate, base chiefly acute, midrib and the few patent nerves conspicuous beneath; terminal leaflet about as long as the general petiole, 5–6×2–2¼ in; exterior leaflets decreasing in size, unequal at base; petiolules 4–8 l. long. Racemes (the male only seen) disposed in a terminal panicle leafy below, peduncles 1–1½ in. long. Calyx 1 l. high, triangular lobes equaling tube. Corolla white; tube 2–3 in. long, 1 l in diam.; lobes oblong-elliptical, 5–7 l. long, dextrorsely (as seen from the inside) convolute. Superior anthers 2 l. long, adnate to somewhat shorter filaments; the inferior opposite to the lobes, sessile, 3½ l. long; connective slightly produced, appendaged on the back with a dilated rubro-punctate membrane a little shorter than the connective and free at the tip. Style from the rudimentary ovary linear, half an inch long. Female flowers and berries not seen.—Readily distinguished by the length of the flowers and structure of the stamens from all species of the doubtfully distinct genera *Carica* and *Jaracatia*. Popularly called *Papaya del Monte*.

Forests bordering the river Zhorquin, Talamanca, Costa Rica, March 1894, *Tonduz*, no. 8509 herb. nat. C. R.—Suerre, Llanos de Santa Clara, Costa Rica, alt. 900 ft., April 1896, *Donn. Sm.*, no. 6526 Pl. Guat., etc., qu. ed. Donn. Sm.

Siphocampylus discolor Donnell Smith.—Frutex pube pallide ochracea totus fere furfuraceus. Folia supra pube sparsim punctata subtus ochracea in costa nervis venis furfuracea obovato-oblonga acuminata deorsum attenuata glandulis passim denticulata. Pedunculi folia aequantes, bracteis filiformibus. Calycis tubus ovalis segmentis linearibus parum brevior. Corollae albae usque ad medium fidae tubus segmentis calycinis vix longior superne inflatus, laciniis inaequalibus falcatis secundis. Antherae majores in vertice nudae, omnes linea media albo-pubescentes ceterum glabrae.

Branchlets subalate by decurrent petioles. Leaves 7–9×2–2½ in., petioles 7–10 l. long. Peduncles from upper axils, glabrescent, bracts 5–10 l. long. Flowers 2½–2¾ in. long. Tube of calyx in anthesis 5–6 l. long; segments 7–10 l. long, glandular-denticulate. Tube of corolla more or less furfuraceous, an inch long, segments linear-lanceolate, the 2 superior ones 12–13 l. long and twice exceeding the others. Staminal column glabrescent; anthers exsert, 7 l. long. Capsule globose-oval, ¾ in. long, pubescent-punctate; ribs 10, furfuraceous.—Nearest to *S. foetidus* G. Don.

Forests of Rancho Flores, Volcán Barba, Costa Rica, alt. 6700 ft., Feb-

ruary 1890, *Tonduz*, no. 2149 herb. nat. C. R.—Forests of Volcán Irazú, C. R., alt. 6200 ft., July 1891, *Tonduz*, no. 4241 herb. nat. C. R.

Siphocampylus roseus Donnell Smith.—Herbaceus glabrescens. Folia longiuscule petiolata ovata acuminata ad basin imam cuneata, denticulis inaequalibus glandula fusca apiculatis. Pedunculi ad basin bracteati folia subaequantes. Calycis tubus turbinatus segmenta linearia serrulata aequans. Corollae roseae segmentis calycinis 6-plo longioris tubus incurvus claviformis, lobi breves oblongi acuminati erecti, laterales falcati, anticus altius solutus. Genitalia inclusa, antheris majoribus sub apice barbatis.

Stem decumbent, repent at base; branches assurgent, 2–3 ft. long, the younger parts cano-pubescent. Leaves alternate, 3¼–5¼ × 1½–3¼ in., glabrous except midrib and nerves of lower surface, petioles ¾–2 in. long. Peduncles axillary, 2–3¼ in. long, puberulous; bracts linear, 2 l. long. Ribs of calyx-tube canescent; segments 3–4 l. long. Corolla puberulous, 1¾–2 in. long; lobes albescent within, the anterior one 5 l. long, the others 4 l. long. Anthers nearly glabrous below the apex. Capsule globose-oval, 8–10 l. long, apex shortly conical.—Related to *S. glandulosus* Hook.

Confluence of the rivers Sarapiquí and Puerto Viejo, Costa Rica, near sea-level, April 1892, *Biolley*, no. 6922 herb. nat. C. R.—Banks of river Pacuare, Comarca de Limón, C. R., alt. 600 ft., April 1896, *Donn. Sm.*, no. 6628 Pl. Guat, etc., qu. ed. Donn. Sm.

LIPPIA SUBSTRIGOSA Turcz., var. **oxyphyllaria** Donnell Smith.—Caules et ramuli teretes. Folia elliptica -aut lanceolato-elliptica e medio utrinque acuminata. Pedunculi 1–2-ni, capitulorum rhachi usque ad 8 l. longa, bracteolis ovato-lanceolatis, extimis longius acuminatis 8–9 l. longis.

Borders of forest at Térraba, Comarca de Puntarenas, Costa Rica, alt. 800 ft., February 1891, *Pittier*, no. 3951 herb. nat. C. R.—Thickets along the river Ceibo near Buenos Ayres, C. R., alt. 1000 ft., February 1892, *Tonduz*, no. 6667 herb. nat. C. R.

The typical form of this species seems to be represented by the following specimens from Guatemala, which differ from the above by tetragonal branches, ovate leaves abruptly contracted into petiole, peduncles several in the axes, orbicular-ovate bracteoles: nos. 2006, 4387, 4389 Pl. Guat., etc., qu. ed. Donn. Sm.; no. 3610 *Nelson*.

Salvia Pansamalensis Donnell Smith. (§ CALOSPHACE, *Longiflorae* Benth)—Caules herbacei glabri. Folia supra parce pilosa

subtus glabra lanceolato-elliptica longe caudato-acuminata deorsum angustata mucronibus exsertis dentata. Racemi foliis reductis fulti in paniculam saepe dispositi, verticillastris bifloris, bracteolis purpureis ellipticis cuspidatis calycem superantibus. Calycis purpurei labia brevissima, posticum subintegrum subtruncatum, antici dentes triangulares. Corollae purpureae tubus ventricosus calyce et labiis subaequalibus 3-plo longior. Genitalia inclusa.

Stems several from a fibrillose root, simple, 1–2½ ft. high. Leaves 4–5½×1–1¾ in., the prolonged tip 5–8 l. long, base and apex not dentate, lower surface pale and minutely reticulated, petioles 3–4 l. long. Racemes 2–4 in. long, closely flowered; pedicels flavo-pubescent, 1 l. long; bracteoles 6 l. long, ciliate. Calyx tubulose-campanulate, 4–5 l. long, nerves ciliate. Corolla pubescent above, smooth within; superior lip oblong and entire, the inferior much broader and oval. Style glabrous. Gland of disk twice longer than nutlets.

Pansamalá forest, Depart. Alta Verapaz, Guatemala, alt, 4000 ft., June 1886, *von Türckheim*, no. 933 Pl. Guat., etc., qu. ed. Donn. Sm. Specimens under this number have already been distributed as *Salvia sp.* to various herbaria.

Costus podocephalus Donnell Smith.—Vaginae elongatae striatae pubescentes in lobos 2 rotundatos breviter productae, foliis glabris subtilissime nervatis elongato-lanceolatis caudato-acuminatis ad basin sessilem acutis. Pedunculus subexsertus bracteatus. Strobilus ovoideus, bracteolis dense imbricatis erectis striatis oblongis, inferioribus obtusis mucronatis, superioribus acuminatis. Flores inclusi. Calyx partitus corolla tubulosa genitalibusque parum brevior.

Leaves 11–13×2½–3 in., minutely rubro-punctate beneath, slender cusp 6 l. long; sheaths sprinkled with a tufted paleaceous pubescence, rubro-punctate; lobes 2–3 l. long, externally tomentulose, internally colored and reticulated. Bracts of peduncle 2, an inch distant, 2–3½ × ½ in., slenderly cuspidate, tomentulose toward apex. Strobile 2½–3¼ in. long, stramineous; bracteoles 15–18×5–6 l., pubescent, the mucro tipped with a deciduous awn. Perianth 5–6 l. long, tomentulose toward apex; calyx-segments lanceolate, conduplicate, the third one obsolete, margins hyaline; corolla striate, the triangular lobes 1½ l. long. Stigma hemispherical, ciliate. Developed staminodes and the capsules not present in the specimens.

Guápiles, Llanos de Santa Clara, Costa Rica, alt. 850 ft., Apr. 1894, *Donn. Sm.*, no. 4972 Pl. Guat. etc., qu. ed. Donn. Sm.—Forests of Shirores, Talamanca, Costa Rica, alt. 300 ft., Febr. 1895, *Tonduz*, no. 9238 herb. nat. C. R.

Myrosma Guapilesense Donnell Smith. (§ SARANTHE)—Folia glabra oblongo-ovalia subito acuminata ad basin imam cuneata, radicalia longissime petiolata, caulinum 1 terminale ceteris nec superatum. Paniculae ad apiceum caulis 2 longe pedunculatae corymbosae, spicis binis dense bracteosis, flore superiori pedicellum aequante, inferiori in medio pedicelli communis subsessili. Sepala petalis latiora vix breviora. Ovarium profunde 9-sulcatum.

Rhizome repent, 3–4 in. long, articulations vaginate, roots fibrillose. Radical petioles distichous, 1 ½ ft. long, nearly glabrous; articles geniculate, 10–11 l. long, puberulous on face. Leaves 10–12 × 4–4 ½ in., the cauline somewhat smaller, its petiole 7 in. long. Flowering stem 13–15 in. long; peduncles pubescent at base, 2 ½–3 ¼ in. long, somewhat exceeding the linear bracts; spikes 1–2 ½ in. long, flexuous; bracteoles distichous, 7–9 l. long, 3–4 times exceeding internodes, at first pubescent, enclosing a pair of flowers. Sepals oblong-elliptical, 4–5 l. long, scarious, glabrous, multinerved, nigro-mucronulate. Petals oblong, acute, nigro-apiculate. External staminodes multinerved, emarginate; appendage of stamen shorter than anther. Ovary shortly cylindrical, 2 ½ × 2 l., slightly pilose at apex, crenately-angular, cell reticulated; ovule 1 ½ l. long, rubescent; aril minute, bifid. Fruit not seen.

Guápiles, Llanos de Santa Clara, Costa Rica, alt. 850 ft., Apr. 1894, *Donn. Sm.*, no 4970 Pl. Guat., etc., qu. ed. Donn. Sm.

GYMNOGRAMME CERATOLEPIS (*Asplenium Ceratolepis* Christ in Bull. Soc. Bot. Belg. **35**: 203), var. **Atirrensis** Donnell Smith.—Pinnae integrae aut leviter crenatae, discretarum venae cunctae adscendentes liberae marginem attingentes, connatarum vena infima cum ea pinnae contiguae juxta rhachin arcuatim conjuncta.

In the typical specimens (no. 1170 herb. nat. C. R.!) the pinnae are lobed to their middle with a conjunctive vein near the midrib. The sori, present in all stages of development, exhibit, as Dr. Christ has also remarked, no traces of an indusium.

Swampy thickets at Atirro, Prov. Cartago, Costa Rica, alt. 1800 ft., Apr. 1896, *Donn. Sm.*, no. 6882 Pl. Guat., etc., qu. ed. Donn. Sm.

BALTIMORE, MD.

CONTRIBUTION TO THE LIFE HISTORY OF SAGITTARIA VARIABILIS.[1]

JOHN H. SCHAFFNER.

(WITH PLATES XX–XXVI)

THE following work upon Sagittaria was begun in October 1896, and is a continuation of my former work on *Alisma Plantago*,[2] to which paper frequent reference will be made for comparison. So far as the writer knows, no special work has been done upon the gametophyte generation of Sagittaria, or upon its embryology. The material used was killed in a solution of chrom-acetic acid and preserved in 70 per cent. alcohol, and the usual methods of imbedding in paraffin and staining on the slide were employed. The stain used for the greater part of the work was a double stain of anilin-safranin and gentian-violet.

The investigation was carried on under the direction of Dr. John M. Coulter, to whom I here express my thanks for assistance and criticism.

The flowers of *Sagittaria variabilis* are all monosporangiate, but frequently there are abortive carpels at the center of the staminate flower. Some varieties are monœcious and others diœcious. The carpels, which become achenes, are spirally arranged upon a very globose receptacle, as are also the stamens. The ovules are apotropous. In the earlier stages they are anatropous, but later they become strongly campylotropous, so that the mature embryo is bent double and becomes horseshoe shaped. Both the staminate and carpellate flowers have nectaries which are active during the blooming period. The nectaries are situated around the base of the flower, between the carpels and the petals. They appear to be simply modified

[1] Contributions from the Hull Botanical Laboratory. IV.

[2] The embryo sac of Alisma Plantago. BOT. GAZ. **21**: 123–132. 1896.

carpels. The glandular secreting cells are epidermal and are situated around the lower part (*fig. 1*), usually extending to the adjoining carpels, which often remain sterile and develop no embryo. The secreting cells begin to enlarge about the time the embryo sac is formed, and after fertilization is accomplished they cease their activity and become more or less shrunken and disorganized. During their active period the cytoplasm of these cells has the characteristic glandular appearance, and the nuclei are drawn out into irregular shapes, often having thick projections like pseudopodia (*fig. 45*).

DEVELOPMENT OF THE MALE GAMETOPHYTE.

As no suitable material was available the early development of the anther was not studied. The pollen mother cells were found dividing abundantly. In these numerous figures in the mother star stage showed large and well defined centrospheres at the poles (*fig. 2*), and although the exact number of chromosomes was not determined the reduction was ascertained to take place at this division. This fact should be kept in mind in connection with any theoretical explanation of the phenomenon of reduction, as it will be seen that the two daughter nuclei arising from the reduction nucleus do not belong to the first cells of the sexual generation, but to the mother cells of the microspores with which the sexual generation properly begins. By the time the nucleus of the pollen mother cells is in the close mother skein stage, two centrospheres appear at each pole of the spindle. By successive divisions the two microspore mother cells form the cells of the tetrad. These cells, which usually lie in one plane (*fig. 4*), soon separate, and with little or no increase in size develop into the microspores. The microspores possess a very thick wall, from whose outer surface are developed prickly projections (*fig. 5*).

The microspore soon begins to enlarge and the first division of its nucleus takes place, giving rise to the generative and tube nuclei. The two nuclei are at first quite similar, but they soon differentiate, the tube nucleus becoming larger, and the gener-

ative nucleus appearing to develop more chromatin, and thus always taking a deeper stain. Although no special staining was employed, centrospheres were frequently seen beside the resting generative nucleus. The pollen grain now rapidly grows to its mature size, and the generative nucleus immediately divides into the two sperm nuclei. These are small and spherical at first, and always stain so deeply that little or no structure can be seen in them (*fig.* 7). This division of the generative nucleus takes place long before the anther has reached its mature size and is ready to dehisce. After the pollen is shed the sperm nuclei no longer appear spherical, but are bean shaped or spindle shaped, and the tube nucleus shows a difference in its reaction, since it now stains almost as deeply as the sperm nuclei themselves, and shows little or none of its internal structure (*figs.* 8, 9). Whether the sperm nuclei organize definite cells I could not determine. The spindle shaped appearance may have been produced by the accumulation of a small amount of cytoplasm at the two ends, but if this was really the case my staining produced no differentiation between nucleus and cytoplasm. The division of the generative nucleus before pollination seems to be quite common in monocotyledons, and it is probable that this condition will be found to be the rule rather than the exception in this group.

DEVELOPMENT OF THE FEMALE GAMETOPHYTE.

Because of a lack of suitable material the development of the macrospore could not be worked out. The earliest stage found was a four-celled embryo sac (*fig.* 10). The two nuclei at the micropylar end arise by longitudinal division, while the two lower ones are produced by a transverse division. After the next divisions, which produce the typical eight-celled embryo sac, the nuclei begin to travel to their proper positions, while at the same time large vacuoles appear in their rear. The nuclei of the synergids, the nucleus of the oosphere, and the lower polar nucleus are about the same size, while the upper polar nucleus is by far the largest nucleus in the sac (*figs.* 11, 12). The three antipodal nuclei are considerably smaller than the others, and

even at this early stage, before the conjugation of the polar nuclei and the act of fertilization, they are often cut off by well defined cell walls (*fig. 11*).

In approaching each other the upper larger polar nucleus travels much farther than the lower one, so that the place of contact is usually in the lower part of the embryo sac (*figs. 14, 19, 25*), and the fusion takes place here without any apparent shifting of the nuclei, the fusion being usually complete before the entrance of the pollen tube into the sac (*fig. 19*). Frequently two centrosomes with a common hyaline area around them can be seen on one or both sides of the conjugating nuclei (*fig. 13*), indicating a possible union of the two pairs of centrospheres which are brought together when the two nuclei approach each other. Later the appearance is as though the two centrosomes had fused (*figs. 15, 16*). Although these observations were not very extensive, they agree with what I observed in the conjugating polar nuclei of *Alisma Plantago*. There is usually one large nucleolus in each polar nucleus, and during the fusion of the polar nuclei their nucleoli also seemed to fuse. When the nuclear fusion is nearly complete, two or three nucleoli appear close together (*figs. 15, 16*), and a little later the nucleoli are seen to lie in contact (*figs. 17, 18*). When nuclear fusion is completed, the definitive nucleus nearly always shows but one large nucleolus (*figs. 19, 29*), so there can be but little doubt from the stages observed that the nucleoli come together and fuse directly as definite bodies, without breaking up or being dissolved.

PHENOMENA OF FERTILIZATION.

Just before the entrance of the pollen tube into the micropyle, the two synergids lie side by side, with the oosphere suspended below and lying somewhat to one side (*figs. 14, 19, 20*). In the lower part of each synergid there is a large vacuole. At this stage the nucleus of the oosphere is usually quite symmetrical, being spherical or ellipsoidal in shape.

It will be remembered that the pollen grain has the two

sperm cells fully differentiated before pollination. As the tube passes through the micropyle it is considerably constricted, but when it reaches the apex of the embryo sac it increases appreciably in diameter. The tube takes exactly the same course as in Alisma, passing down on one side near the wall of the sac, and encountering the nucleus of one of the synergids, which disappears at this time and is never seen again (*figs. 21, 25, 26, 29*). The other synergid, with its nucleus, persists for a long time, and can still be seen above the vesicular suspensor cell of rather large embryos (*figs. 65, 69*). The pollen tube after entering the embryo sac stains very dark, and it is often difficult to distinguish the two sperm nuclei as they are traveling down the tube. In lightly stained material, however, they can be seen very readily. As the lower one approaches the tip of the tube it is preceded by two centrospheres, which can be seen always in well stained sections because of their position and the light colored cytoplasm with which they are usually surrounded (*figs. 22, 23, 24, 26, 28*). When the sperm nucleus breaks out of the tube it makes a decided perforation, the appearance being as though the tip had been softened and the nucleus had broken forcibly out of it. In some cases the edges of the perforation are rather smooth, while in other cases they are somewhat ragged (*figs. 29, 30, 31, 32*). A stream of cytoplasm escapes from the tube after the lower sperm nucleus (*fig. 30*), but the upper sperm nucleus never leaves the tube (*fig. 32*), which is also the case in Alisma. After the rupture of the pollen tube, the cytoplasm between the sexual cells usually contains numerous granules, which may have escaped from the tube, or they may be fragments of the disintegrated tip of the tube (*figs. 25, 27*). This often makes it difficult to identify the centrospheres at this stage, it being very easy to lose sight of them entirely although they may be present in the section.

In the meantime changes have been taking place in the oosphere. Its nucleus is no longer symmetrical in outline, but, just as in Alisma, it is drawn out into a considerable bulge on the side toward the sperm nucleus (*figs. 21, 24, 29, 30*). This

bulging of the female nucleus toward the male nucleus has also been observed in *Pinus Banksiana* and *P. Laricio*.[3] In the case of the large female nucleus of Pinus, however, the bulging appears only as a papilla-like protuberance, while in Alisma and Sagittaria the whole side of the nucleus appears to be drawn out. What the physiological significance of this bulging is cannot be stated, but it seems to be one of the characteristic phenomena of fertilization in the higher plants.

Although the method of staining employed did not bring out the centrospheres of the oosphere nucleus as readily as those of the sperm nucleus, they were sometimes seen, and when they appeared they were found lying just beyond the bulge of the oosphere nucleus toward the sperm nucleus (*fig. 21*). Thus, during the approach of the two sexual nuclei each one is preceded by its two centrospheres. Just before the contact of the sexual nuclei, two pairs of centrospheres appear on opposite sides of the approaching nuclei (*fig. 30*), and when the nuclei are in contact a little later, the two pairs appear to be fusing (*fig. 31*). These appearances are the same as those I observed during the fusion of the polar nuclei of Alisma, and seem to point strongly to a pairing and subsequent fusion of the four centrospheres which are thus brought together. Although these appearances very properly can receive such an explanation, it must be borne in mind that other movements and other explanations are possible. Thus, the two centrospheres which appear on the upper side in *figs. 30* and *31* may be interpreted as belonging to the female nucleus, while the lower pair may have come from the male. This would do away with the so-called "quadrille movement." I think, however, that Guignard's explanation of a conjugation in pairs is the more reasonable one, from the fact that during fusion of cells not only the nuclei themselves fuse, but apparently also the cytoplasm, chromatophores, and pyrenoids, indicating that during fusion all protoplasmic bodies of the same nature in the cells are involved in the act. The evidence which led me to infer a pairing of centrospheres during

[3] Bot. Gaz. 23: 40, 41. 1897.

the fusion of the polar nuclei in Alisma was the fact that just before the contact of the nuclei the centrospheres appeared a little farther apart as though they were separating. The interpretation in such cases, however, necessarily must be merely an inference, and could not be decided absolutely except by observing the phenomena in the living condition, which at present seems entirely out of the question in the case of the higher plants, unless a system of differential centrosphere stains can be developed. The whole subject must depend upon the question as to whether centrospheres are permanent bodies in the cell and deserve to rank with other cell organs. Although our knowledge in regard to these bodies is still too fragmentary to make any positive assertions, the permanent organ theory certainly seems to be receiving constantly new confirmation. Recently Lauterborn[4] has studied these bodies in certain diatoms, in which he was able to see centrosomes very readily, even in the living condition. This is a direct confirmation of the work done by Bütschli,[5] who made the same observation in 1891. As far as my own observation goes, I can come to no other conclusion. These bodies appear so often that they can not be overlooked by a careful observer. They appear beside the resting nucleus, in the higher plants always two in number, and later at the poles of the spindle in the mother star stage. A little later, having divided into two, two centrospheres appear at each pole of the spindle, sometimes so prominent that they are as much in evidence as the nucleus itself (*fig. 34*). There is no reason why at times, especially during abnormal conditions, the centrospheres should not fragment or break up into a number of pieces, just as is the case with the nucleus, but any objections raised as to the individuality of centrospheres because of such action can have no more weight than a similar argument against the individuality of the nucleus because it frequently fragments or dissolves. It makes little difference what the function of the

[4] Untersuchungen über Bau, Kernteilung und Bewegung der Diatomeen. Aus dem Zoologischen Institut der Universität Heidelberg. Leipzig, 1896.

[5] Über die sogenannten Centralkörper der Zelle und ihre Bedeutung. Verhandl. des Naturhist.-Med. Vereins zu Heidelberg. N. F. 4: 535-538. 1891.

centrosphere is finally discovered to be; the presence of the body must be explained. That its function may have been misinterpreted is no argument against its existence. The centrosome may be a mere insertion point for spindle threads and cytoplasmic radiations, as Heidenhain seems to suppose; it may be the special organ of division and a truly directive sphere; it may be even more, and have some function in transmitting hereditary characteristics; but whatever its function may be, the point to be decided first is its existence. If this is established, questions as to its origin, purpose, and permanency naturally follow.

The appearance of two centrospheres at the poles of the spindle (*figs. 3, 34*), it seems to me, cannot be explained by a crossing of cytoplasmic filaments; by an attraction from the periphery to a common center; or by the rather lately broached idea of a sort of whirlpool in the cytoplasm. So far as the writer is able to judge, no one has attempted to offer a satisfactory explanation of these double centers at the poles on the theory of their temporary nature, since he called attention to them in 1894.[6] At this stage these bodies can be identified readily, and there is no danger of mistaking other granules of the cytoplasm for centrospheres.

In this connection I wish to refer to Humphrey's[7] implied criticism of my former work on centrospheres. He intimates that, having largely used Hermann's method of staining centrospheres, I may have mistaken various proteid granules in the cytoplasm for true centrospheres. My only reply to this is that I was fully aware of the fact that many small bodies in plant cells often greatly interfere with the identification of centrosomes, and, therefore, a large number of stains and methods of killing were used in order to eliminate any faulty observations which might be possible in using only a single method of preparation. It must be recognized that methods of fixing and staining do not give the same results when used by different observers.

[6] The nature and distribution of attraction spheres and centrosomes in vegetable cells. BOT. GAZ. **19**: 449. 1894.

[7] On some constituents of the cell. Ann. Bot. **9**: 574. 1895.

Even plants of the same species and different parts of the same plant, when treated in exactly the same way, will react quite differently, and one must practically invent a new process for every form studied if reliable results are to be obtained.

THE ANTIPODAL REGION.

As already stated, the three antipodals are surrounded at an early stage by very definite cell walls, although in certain cases the formation of walls may be delayed for some time. When the embryo is two-celled, the embryo sac is still quite narrow, and tapers very gradually into the antipodal region (*figs. 36, 37, 39*); but after this it widens out greatly, leaving the antipodal region, which in the meantime has developed very thick cell walls, as a sort of vermiform appendix to the lower part of the sac (*figs. 40, 41, 42, 43*). The antipodal region, with its three nuclei, persists even in the fully formed ovule, where it always produces a very striking appearance because of the constancy with which it preserves its original shape and dimensions. In these late stages, however, the antipodal nuclei stain a very deep color, so that they appear almost entirely homogeneous (*figs. 40, 41, 42, 43, 44, 73*). It is probable that this persistence of the antipodal region may be much more common than is generally supposed, and that it may often have been overlooked and reported as disappearing when it was actually present and persisting even in the mature ovule.

DEVELOPMENT OF THE ENDOSPERM.

In the development of its endosperm Sagittaria presents some very interesting peculiarities. The first division of the definitive nucleus takes place about the same time as the first division of the oospore; and what is most remarkable, at this division a cell plate is formed between the daughter nuclei, which cuts the embryo sac transversely into two compartments (*figs. 36, 37, 38, 39*). This transverse wall will be called the partition wall. Because of the difference in the behavior of these two nuclei, to avoid ambiguity, the one on the micropylar

side of the partition wall will be called the upper endosperm nucleus, and the one on the antipodal side of the partition wall the lower endosperm nucleus.

The upper endosperm nucleus immediately begins to travel upward on the convex side of the embryo sac wall, and immediately begins a rather rapid free nuclear division (*figs. 37, 38, 39*). At the same time the ovule takes on its campylotropous shape, the sac almost doubling on itself, and the elongation practically all taking place above the partition wall (*figs. 38, 41, 73*). In the early stages the free endosperm nuclei are about equally distributed from the embryo down to the partition wall. After the embryo has reached nearly the mature condition the numerous free endosperm cells, which in the meantime have accumulated above the partition wall, begin an active process of free cell wall formation, forming quite a large cap, which extends over the tip of the cotyledon and crowds down upon the partition wall, forcing its outer margin downward (*figs. 44, 73*).

In the meantime no such process has been going on in the compartment below the partition wall. The lower endosperm nucleus does not divide for a long time, but increases considerably in size (*fig. 40*). Its first division usually occurs at the time when the embryo is about seven or eight celled, and it is nearly always divided when the embryo is from nine to eleven celled. Sometimes one of the nuclei may divide again, thus producing three nuclei (*fig. 43*), or it may be that the three nuclei were produced by direct division. No more than three nuclei were observed in any stage, although it is possible that sometimes there may be more. These nuclei increase enormously in size, being as large or even larger than the giant nucleus of the vesicular suspensor cell. They are nearly always closely crowded together (*fig. 43*), and at the time of the free cell wall formation of the upper endosperm they appear to break up and take on the deep stain which is characteristic of the antipodal nuclei (*fig. 44*). When the ovule has reached maturity, all that can be seen of these nuclei is an irregular mass of red stained material situated just above the antipodal region in a sort of pocket

cut off by the partition wall (*fig. 73*). Just what the function of these lower endosperm cells may be the writer is not prepared to state. In the earlier stages the whole compartment has a glandular appearance, much like the vesicular cell of the suspensor. It seems possible, therefore, that it may play an important part in the transfer of food material from the funicular region, beyond the antipodals, to the cotyledon, and especially in facilitating the formation of the cap of endosperm which covers the tip of the cotyledon.

DEVELOPMENT OF THE EMBRYO.

After fertilization the large spherical nucleus of the oospore lies in about the same position as that occupied by the oosphere nucleus before fusion (*fig. 32*). The oospore now begins to push downward into the sac and is surrounded by a definite cell wall, and usually one or more large vacuoles appear above it (*figs. 33, 35*). The formation of vacuoles in the rear of moving nuclei seems to be of quite general occurrence, especially in the embryo sac. The nuclei seem to be carried along by the streaming of the cytoplasm, which as it advances develops a vacuole behind it.

The first division of the oospore is transverse (*figs. 36, 38, 39*). After this the lower cell elongates and divides again by a transverse wall, making the first three cells of the pro-embryo, which are thus produced in acropetal succession (*fig. 46*). The upper cell never divides, and forms the vesicular suspensor cell, which immediately begins to increase enormously in size. The lowest cell gives rise to the terminal cotyledon, and its first division, which may occur immediately (*fig. 47*) or may be delayed for a considerable length of time, is always longitudinal. The middle cell gives rise to the apex of the stem, the hypocotyl, the root tip, and all the suspensor cells except the vesicular cell, its divisions occurring in basipetal succession. The general course of events, therefore, is the same as that given by Hanstein and Famintzin for *Alisma Plantago*, except in certain details and variations which will be mentioned later, and

does not agree with my own observations on the early development of the embryo of Alisma, where I found four cells produced in acropetal succession before the longitudinal division of the terminal cell. I am inclined now to regard this as only an exceptional variation. However, such a variation may also occur in Sagittaria, since the succession of divisions of individual cells in an embryo does not seem to be so invariable as was once supposed. Sometimes as many as five cells in a single chain were observed without any indication of a longitudinal division in the terminal cell (*fig. 52*). In such a case, of course, it is impossible to tell just how the various cells originated unless one is fortunate enough to find cases in which the nuclei are in the spindle stage.

I do not consider it proper in this case to call the terminal cell, which gives rise to the cotyledon, the embryo cell, but shall call it what it really is, the cotyledon cell. Nor does it seem reasonable to include the middle cell in the suspensor. It will be seen that the development of the embryo proceeds gradually, and to call one cell a suspensor cell which at the next division becomes a cell of the embryo, is drawing an arbitrary line where none exists. The cell at the upper or micropylar end can be called properly a suspensor cell, since it never contributes to any part of the embryo proper, but is subsequently destroyed. The cells which finally become a permanent part of the suspensor between the vesicular cell and the embryo are variable in number and are a late development. There is always, except in rare cases, at least one cell between the developing embryo and the vesicular suspensor cell, which by basipetal divisions contributes to the development of the root-tip, and finally develops a filamentous suspensor, and this cell may be called a temporary suspensor cell. But it seems to me that in cases like Sagittaria the only reasonable terminology is to regard as embryo cells all those which go to make up the embryo, and to restrict the term suspensor to that part which never contributes to the formation of the embryo.

Taking the usual course of events, the third division is in

the middle cell, which divides transversely, making a chain of four cells (*figs. 46, 48*). The succeeding division is in the terminal cell, which divides longitudinally, giving rise to the first two cells of the cotyledon (*figs. 49, 50*). The cell *b* (*fig. 49*) gives rise to the stem tip, while the cell *d* (*fig. 49*) divides transversely, forming the six-celled pro-embryo with five tiers of cells (*figs. 51, 53*). The next division is in the cell *b*, which divides longitudinally (*figs. 54, 55*), and gives rise to the seven-celled pro-embryo (*fig. 56*). During this time the remaining synergid is a very active cell, and appears to assist the vesicular cell in its function (*figs. 46, 48, 54, 55*). There now occur several divisions in rapid succession, but not always in the same order. Usually the two terminal cells divide longitudinally; the cell *d* (*fig. 59*) also divides longitudinally; while in the cell above this transverse division occurs, giving rise to an eleven-celled pro-embryo with six tiers of cells (*figs. 57, 58, 59, 60, 61*). Each one of the four terminal cells now divides transversely (*fig. 62*), so that the young cotyledon becomes an octant. That the process is not always so typical will be seen from *fig. 63*, where one of the four cells has divided longitudinally, and another one is dividing transversely, while there are only five tiers of cells.

After the formation of the octant of the cotyledon, the next thing which usually occurs is the cutting off of the dermatogen by periclinal divisions in these eight cells, and the same process usually goes on in the tier above at the same time (*fig. 64*). The cell in tier *e* (*fig. 64*) now divides longitudinally, while the cell *f* (*fig. 64*) still remains single (*fig. 65*). In one case, however, I observed that this cell *f* (*fig. 66*) also had divided longitudinally. This is a very interesting variation, since it would change the entire course of the development of the root tip and suspensor. It is another illustration showing that no hard and fast lines can be drawn for the development of an embryo. The early stages of the embryo are quite apt to show variations which from their fundamental character must change the whole future course of development. The predestination of cells for

a certain fixed course of development agrees neither with our present ideas of development nor with observed facts.

Taking up again the general course of embryonic development, we have next the differentiation of the apical area of the stem, which begins in a hypodermal cell of tier *b* (*fig. 67*). Another transverse division of the cell *f* (*fig. 64*) occurs, while at the same time the cotyledon also undergoes further development (*figs. 67, 68, 69*). It will be noticed, therefore, that the cotyledon is the earliest region to be developed, and that the apex of the stem follows. The development of the apical region of the stem is continued by transverse divisions of the neighboring dermatogen cells of tier *b* (*fig. 69*), and later the remaining cells of this tier also divide by transverse walls (*fig. 70*). At this stage the vesicular suspensor cell appears to be in its most active condition, but from this time on it begins to disorganize. At this time, and for some time later, the entire embryo is meristematic, and division may take place in any part. In the meantime, after considerable growth, the cell *g* (*fig. 70*) divides by a transverse wall, forming another tier *h*, the lower cell dividing again longitudinally into four cells (*fig. 71*). Whether tiers *e* and *f* (*fig. 71*) arise from tier *e* (*fig. 70*) I could not determine, although from the difference in size of the cells of the two tiers it seems probable that they do not. The embryo now begins to elongate, showing a deep depression on the side where the stem apex is situated, and there is a farther development of cells between the embryo and the vesicular cell (*fig. 72*). At this stage the embryo sac is of almost mature proportions, and the embryo as it grows downward bends around the curve of the sac, very likely because of the mechanical resistance offered by the walls within which it is confined, and thus acquires its hooked form (*fig. 73*.)

DIFFERENTIATION OF DERMATOGEN, PERIBLEM, AND PLEROME.

The development of dermatogen begins at the apex of the cotyledon, and as the embryo develops the dermatogen extends farther and farther toward the point where the apex of the root

will finally be developed. Just how many tiers of cells go to make up the hypocotyl and root tip it seems impossible to determine; in some cases, no doubt, more tiers than in others, since the growth upward seems to have no special definite limit. A variable number of suspensor cells are developed. Sometimes as many as six cells are left for the suspensor, besides the vesicular cell, after the definite limits of the embryo are determined by the completion of the dermatogen around the root tip (*fig. 75*). At this stage the suspensor is usually broken. The dermatogen is thus fully developed before the plerome strand is differentiated enough to be recognized. A hypodermal cell of the root tip is differentiated, and by transverse division forms the initial cell of the plerome strand (*figs. 76, 77, 78, 79*), while at the same time the central primary meristematic tissue is developed into the plerome by longitudinal cell divisions. The plerome and periblem in most cases can be traced downward to this initial cell. The calyptrogen is developed by transverse divisions of a small number of dermatogen cells of the root tip, which by further divisions form a very small root cap for the young embryo (*figs. 77, 78, 79*).

The arrangement of tissues in the mature embryo is well shown by cross sections. At the apex a single central cell appears (*fig. 80*), and a little farther up the differentiation of the plerome strand and periblem are well marked out (*fig. 81*). A section about through the center of the hypocotyl shows a well-marked dermatogen, and inside of this three layers of large periblem cells with large intercellular spaces. In the center the plerome is composed of a bundle of twelve or more long narrow cells, surrounded by a circle of nine or more larger cells forming a sheath (*fig. 82*). Finally, a longitudinal section through the stem apex shows a very deep cleft with the first leaflet already somewhat developed (*fig. 83*).

SUMMARY.

1. Broadly speaking, the development of the pollen grain, embryo sac, and embryo of *Sagittaria variabilis* is the same as in

Alisma Plantago, although there are some striking and important differences.

2. The generative nucleus divides into the two sperm nuclei long before the dehiscence of the anther, making a three-nucleated pollen grain.

3. In the eight-celled embryo sac the upper polar nucleus is by far the largest, and the point of contact and of fusion of the two polar nuclei is in the lower part of the sac, the fusion usually being completed before fertilization.

4. During the fusion of the polar nuclei the centrospheres and nucleoli also appear to fuse.

5. The three antipodal cells are usually surrounded by cell walls before fertilization, and the antipodal region, having developed unusually thick walls, retains its original size and contents even when the embryo is fully formed, projecting somewhat like a vermiform appendix beyond the limits of the enlarged sac.

6. After conjugation, the first division of the definitive nucleus takes place at about the time of the division of the oospore, and at this first division a cell plate is formed making a partition wall which completely separates the embryo sac into two parts.

7. The lower endosperm nucleus divides once or twice, forming two or three free nuclei which enlarge enormously and seem to disintegrate when the embryo is mature.

8. The growth and curving of the embryo sac is practically all above the partition wall; and in this part the upper endosperm nucleus forms many small free cells, those aggregated in the lower part, above the partition wall, finally being surrounded by cell walls and forming a sort of cap over the tip of the cotyledon.

9. The pollen tube expands as it enters the embryo sac and passes down on one side past one of the synergids, which disappears at this time.

10. The two sperm nuclei both enter the embryo sac with the pollen tube, but only one leaves the tube and takes part in fertilizing the oosphere.

11. The sperm nucleus is nearly always seen with two very

distinct centrospheres preceding it as it passes through the tip of the tube.

12. When the sperm nucleus passes out of the tube, the apex of the tube appears to soften, and the sperm nucleus, with its centrospheres, appears to break out abruptly, leaving a distinct opening in the tip of the tube, the edges of which often appear ragged; and from this perforation cytoplasm is seen to escape after the sperm nucleus.

13. At the approach of the pollen tube the nucleus of the oosphere is greatly affected, being drawn out into a large bulge toward the approaching male cell. Sometimes two prominent centrospheres appear just on the top of this bulge.

14. Centrospheres appear in resting nuclei and in division stages, and just before the contact and during the fusion of the two sexual nuclei two pairs of centrospheres appear, which seem to fuse simultaneously with the sex nuclei.

15. The remaining synergid persists for a long time above and somewhat to one side of the vesicular suspensor cell, apparently in an active and healthy condition.

16. After fertilization the oospore pushes downward and divides by a transverse wall.

17. The second division of the pro-embryo is in the lower cell, also by a transverse wall. Of the three cells thus developed in acropetal order, the uppermost cell never divides again, but enlarges greatly, forming the vesicular suspensor cell; the lowest develops into the cotyledon, while the middle cell gives rise, by an indefinite number of divisions in basipetal order, to the stem apex, hypocotyl, root tip, and a few suspensor cells.

18. The cell divisions during the formation of the embryo do not occur in regular order, and though the succession of cells follows some general plan, there are frequently remarkable variations which must necessarily change the whole course of development.

19. The cotyledon is first differentiated, and next the stem apex, which develops from a lateral hypodermal cell in the first tier above the terminal cotyledon cell. The hypocotyl develops

from one or two tiers above the stem apex tier, while the root apex develops from an undetermined tier above the hypocotyl region.

20. Beyond the root apex a short suspensor of a single chain of cells, variable in number, connects the embryo with the large vesicular suspensor cell.

21. In the mature embryo the dermatogen, periblem, plerome, and calyptrogen are well differentiated, the plerome strand and periblem cylinder terminating in a single initial cell just within the calyptrogen layer.

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EXPLANATION OF PLATES XX–XXVI

PLATE XX.

FIG. 1. Section of a nectary showing the position of the secreting cells. × 90.

FIG. 2. Pollen mother cells in the mother star stage, with centrospheres at the poles. × 800.

FIG. 3. Pollen mother cell with two centrospheres at each pole. × 800.

FIG. 4. Tetrad stage. × 800.

FIG. 5. Microspore. × 800.

FIG. 6. Pollen grain with two nuclei; the generative nucleus has two centrospheres. × 800.

FIG. 7. Pollen grain with the generative nucleus divided into the two sperm nuclei. × 800.

FIGS. 8 and 9. Mature pollen grains. × 800.

FIG. 10. Embryo sac with four nuclei. × 800.

FIG. 11. Mature eight-celled embryo sac; the antipodals are already surrounded by definite cell walls. × 800.

PLATE XXI.

FIG. 12. Outline sketch of mature eight-celled embryo sac, showing relative size of the nuclei. × 600.

FIG. 13. Conjugating polar nuclei, showing one pair of centrospheres. × 600.

FIG. 14. Embryo sac with the polar nuclei partly fused; the antipodal cells are without walls. × 600.

FIG. 15. Definitive nucleus nearly complete, with a pair of fused centrospheres on opposite sides; the two nucleoli are still distinct. × 600.

FIG. 16. Definitive nucleus with three nucleoli distinct, and two centrospheres on opposite sides. × 600.

FIG. 17. Definitive nucleus with two large nucleoli apparently fusing. × 600.

FIG. 18. Definitive nucleus with one small nucleolus and two large fusing nucleoli. × 600.

FIG. 19. Embryo sac showing one synergid, the oospore, the definitive nucleus, and two antipodals; the definitive nucleus has but one large nucleolus. × 600.

FIG. 20. Upper end of an embryo sac, showing the arrangement of the egg apparatus. × 600.

FIG. 21. Upper end of embryo sac with pollen tube entering; the oosphere nucleus with two prominent centrospheres. × 600.

FIG. 22. Upper end of an embryo sac with pollen tube; one sperm nucleus in the tip of the tube preceded by two centrospheres. × 600.

FIG. 23. Pollen tube with a sperm nucleus at the tip preceded by two centrospheres. × 600.

PLATE XXII.

FIG. 24. Upper end of embryo sac with pollen tube; two sperm nuclei in the tube, the one at the tip preceded by two centrospheres. × 600.

FIG. 25. Embryo sac with definitive nucleus, one antipodal, one synergid, oosphere, and pollen tube with two sperm nuclei; several granules between the oosphere nucleus and the sperm nucleus at the tip of the tube. × 600.

FIG. 26. Upper end of embryo sac with pollen tube. × 600.

FIG. 27. Upper end of embryo sac; the lower sperm nucleus is just leaving the tube, and between it and the oosphere is a mass of granular protoplasm. × 600.

FIG. 28. Upper end of embryo sac; the sperm nucleus with prominent centrospheres has left the tube and is approaching the oosphere. × 600.

FIG. 29. Part of an embryo sac with definitive nucleus, oosphere, and pollen tube; the oosphere nucleus is greatly bulged out on the side toward the sperm nucleus; sperm nucleus just leaving the tube. × 600.

FIG. 30. Upper end of embryo sac; the sperm nucleus has just left the pollen tube, which shows a perforation at the tip from which protoplasm is escaping; four very prominent centrospheres appear at the two angles of the approaching sexual nuclei. × 1125.

FIG. 31. A little later stage than *fig. 30;* the sexual nuclei are in contact, and two pairs of centrospheres appear above and below; one of the synergids lies in front of the tube, the other has disappeared. × 1125.

FIG. 32. Upper end of embryo sac after fertilization, with large spherical oospore nucleus, and pollen tube containing the remaining sperm nucleus. × 1125.

FIG. 33. Oospore beginning to descend; the pollen tube is beginning to disappear; above the oospore lies the remaining synergid. × 600.

FIG. 34. A cell from the tip of a young embryo with nucleus in the daughter skein stage: two large centrospheres at each pole. × 850.

PLATE XXIII.

FIG. 35. Upper end of embryo sac with oospore and synergid. × 400.

FIG. 36. Embryo sac with a two-celled pro-embryo; two endosperm nuclei separated by a distinct cell wall stretching across the sac, and three antipodal cells. × 400.

FIG. 37. Lower end of embryo sac, a little later than *fig. 36*, showing the position of the first two endosperm cells and the cell wall between them. × 400.

FIG. 38. Embryo sac with a two-celled pro-embryo and two endosperm cells separated by a cell wall. × 400.

FIG. 39. About the same stage as *fig. 38;* the upper endosperm nucleus is dividing. × 260.

FIG. 40. Lower end of an embryo sac which contains a nine-celled pro-embryo; the upper endosperm nucleus has divided into many free cells while the lower remains undivided; at the base two antipodals. × 400.

FIG. 41. Complete embryo sac with a nine-celled pro-embryo containing a number of comparatively small free endosperm nuclei; the endosperm nucleus below the partition wall has divided into two nuclei which have greatly enlarged; two antipodals appear at the lower end of the sac. × 66.

FIG. 42. Lower end of an embryo sac containing a ten-celled pro-embryo; the lower endosperm nucleus has divided into two; the antipodal region with very thick walls retaining its original size and contour. × 216.

FIG. 43. Lower end of an embryo sac in which the lower endosperm nucleus has divided into three. × 400.

FIG. 44. Lower end of an embryo sac with embryo at the stage represented in *fig. 72;* the antipodal region is still distinct and contains the three original nuclei; the lower endosperm nucleus has remained undivided; above the partition wall the sac is filled for some distance with endosperm tissue produced by the upper endosperm nucleus. × 216.

FIG. 45. Secreting cells from a nectary showing the appearance of the cytoplasm and nuclei. × 400.

PLATE XXIV.

FIG. 46. Three-celled pro-embryo with synergid (*s*) on the side of the vesicular cell *a*; middle cell (*b*) dividing. × 400.

FIG. 47. Three-celled pro-embryo with terminal cell dividing. × 400.

FIG. 48. Four-celled pro-embryo with synergid (*s*) beside the vesicular cell; the free nucleus is endosperm. × 400.

FIG. 49. Four-celled pro-embryo with terminal cell (*c*) dividing. × 400.

FIG. 50. Five-celled pro-embryo. × 400.

FIG. 51. Five-celled pro-embryo with the two middle cells dividing. × 400.

FIG. 52. Five-celled pro-embryo with the cells in a single row. × 400.

FIG. 53. Six-celled pro-embryo with synergid above the vesicular cell. × 216.

FIG. 54. Six-celled pro-embryo with synergid. × 400.

FIG. 55. Seven-celled pro-embryo with synergid above the vesicular cell; the two lowest cells each with a cell beneath, which does not appear in the figure. × 400.

FIG. 56. Seven-celled pro-embryo; the free nuclei are endosperm. × 216.

FIG. 57. Seven-celled pro-embryo with one of the cells at the tip dividing. × 400.

FIG. 58. Upper end of embryo sac with a nine-celled pro-embryo; the nucleus above the vesicular cell belongs to the synergid. × 216.

FIG. 59. Ten-celled pro-embryo. × 400.

FIG. 60. Ten-celled pro-embryo; the two cells not shown belong to lowest tier. × 216.

FIG. 61. Eleven-celled pro-embryo with synergid. × 400.

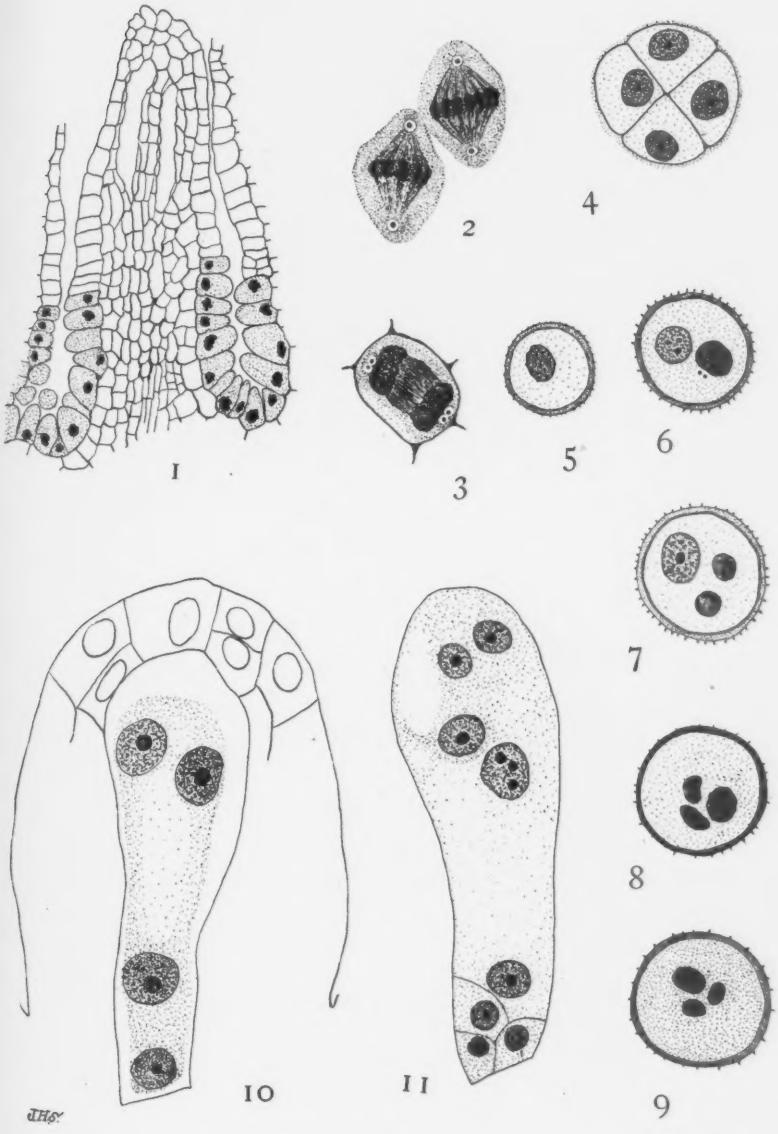
PLATE XXV.

FIG. 62. Twelve-celled pro-embryo with synergid; two cells in the lowest tier not shown. × 400.

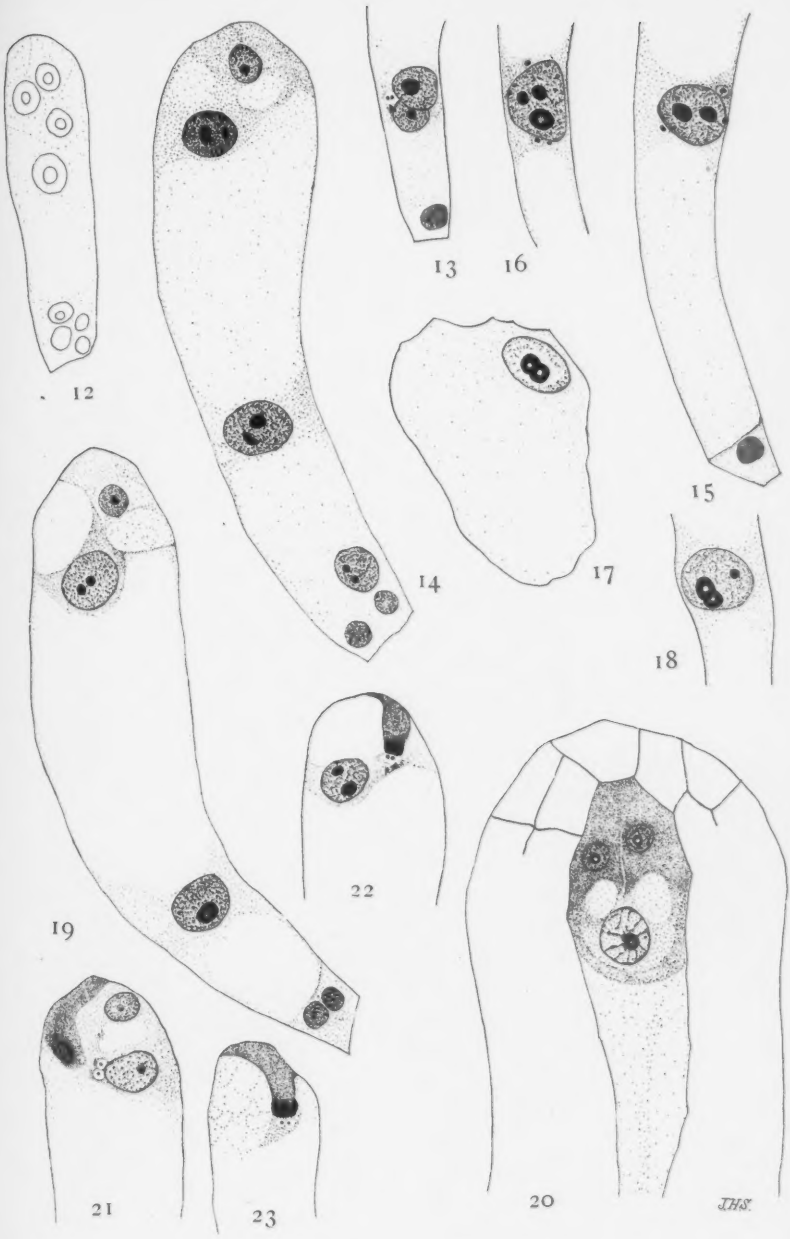
FIG. 63. Eleven-celled pro-embryo; the two cells not shown belong to lowest tier. × 400.

FIG. 64. Embryo with dermatogen cut off from the octant which forms the cotyledon. × 260.

FIG. 65. Embryo showing the appearance of the synergid and vesicular cell at this stage, and further development of the dermatogen. × 400.



SCHAFFNER on SAGITTARIA VARIABILIS.



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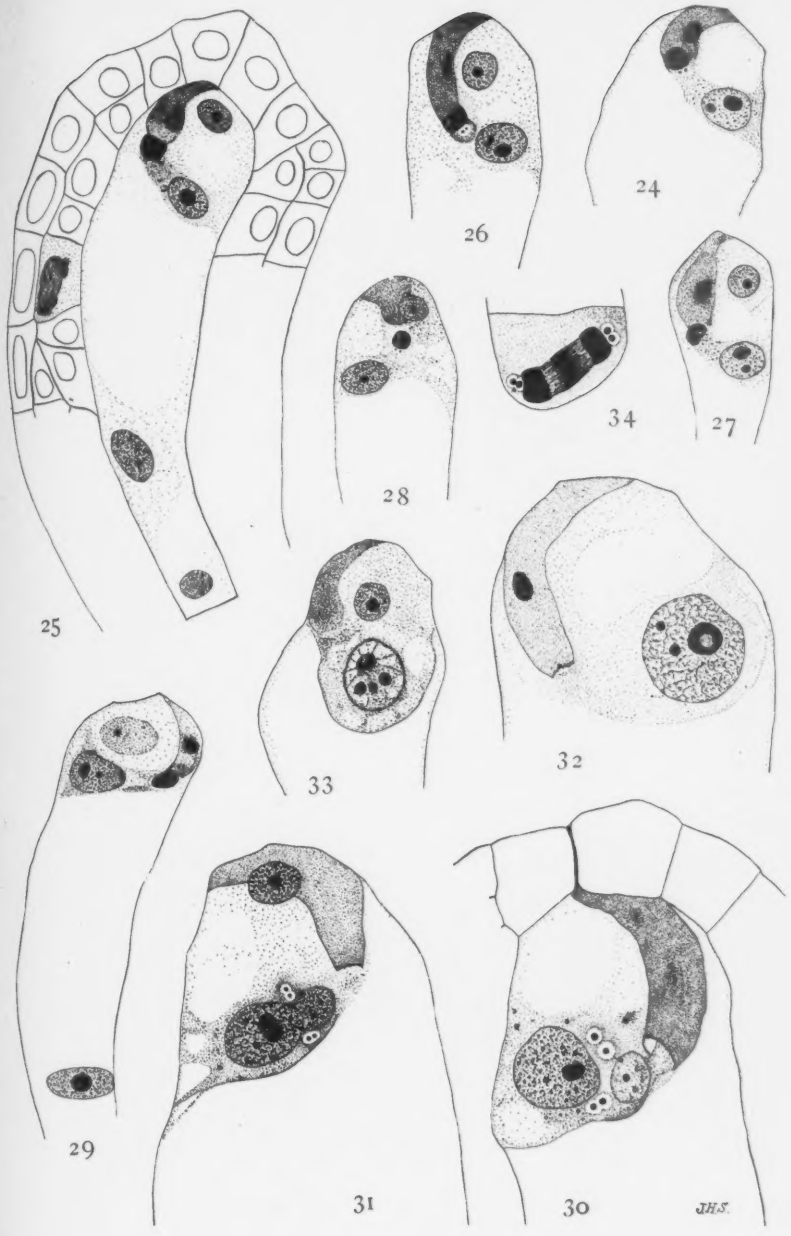
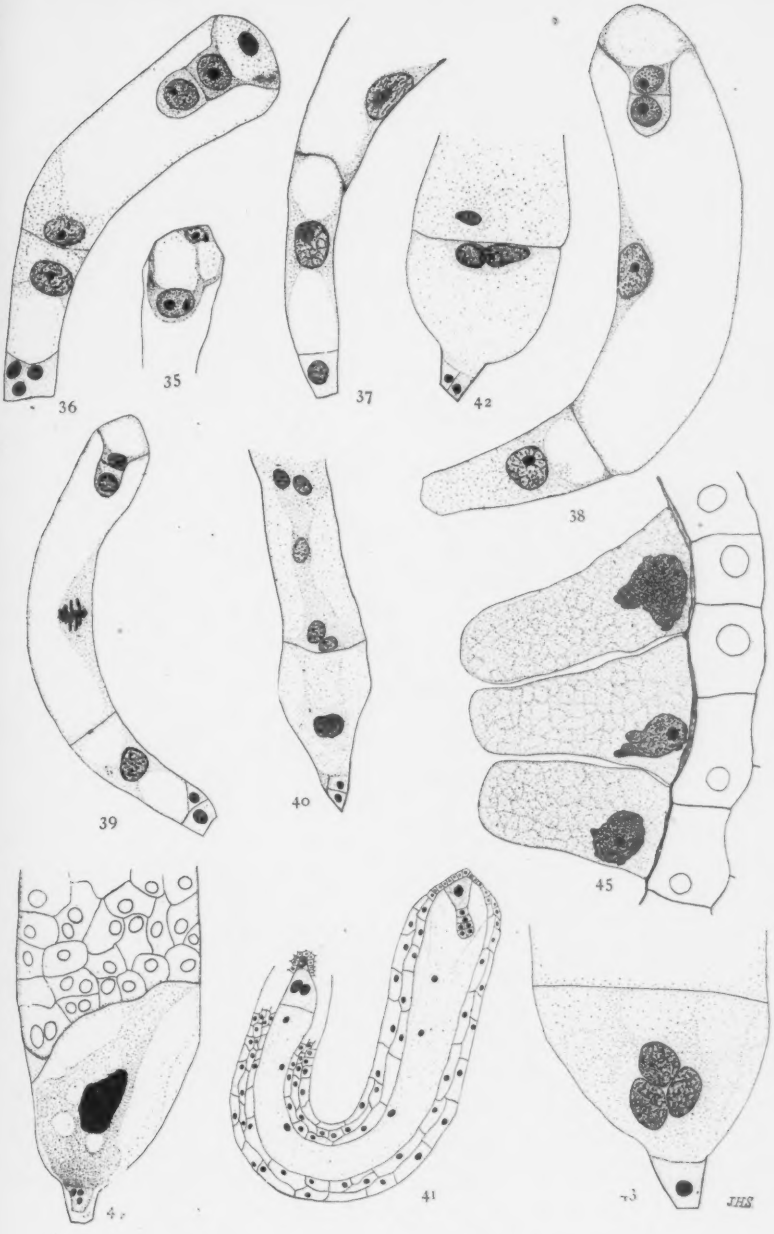
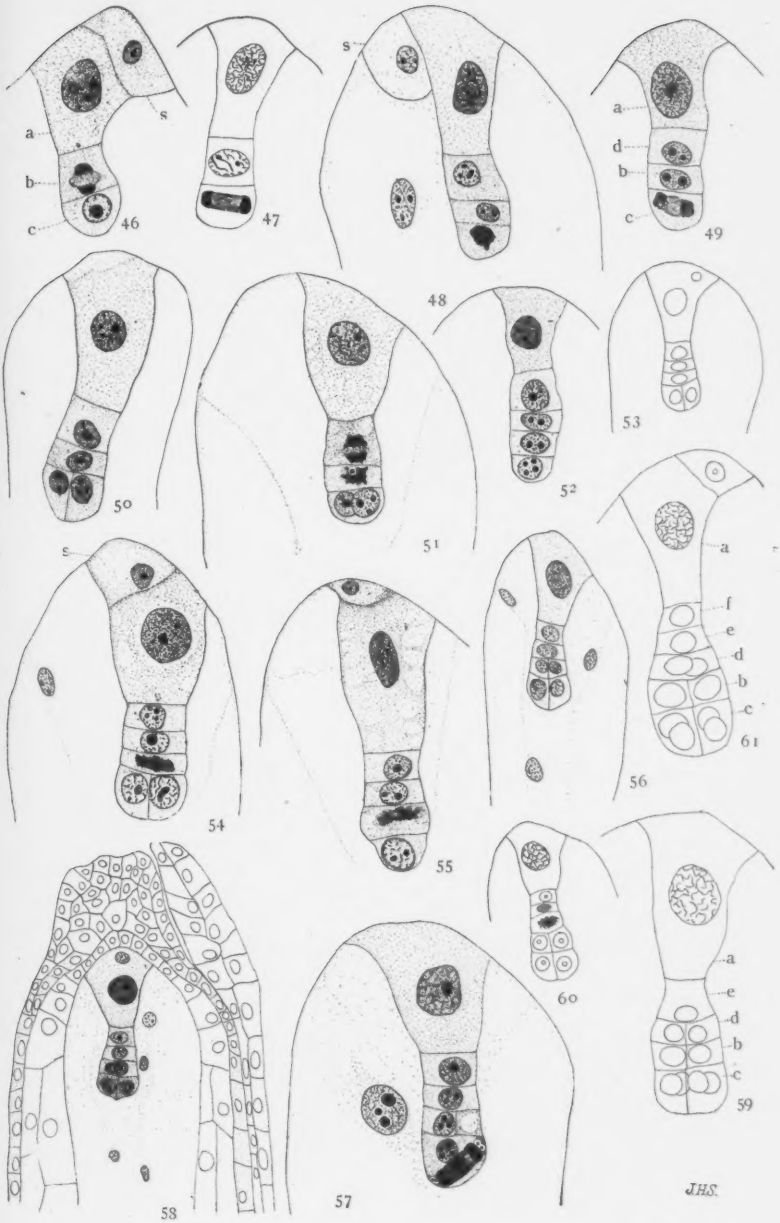


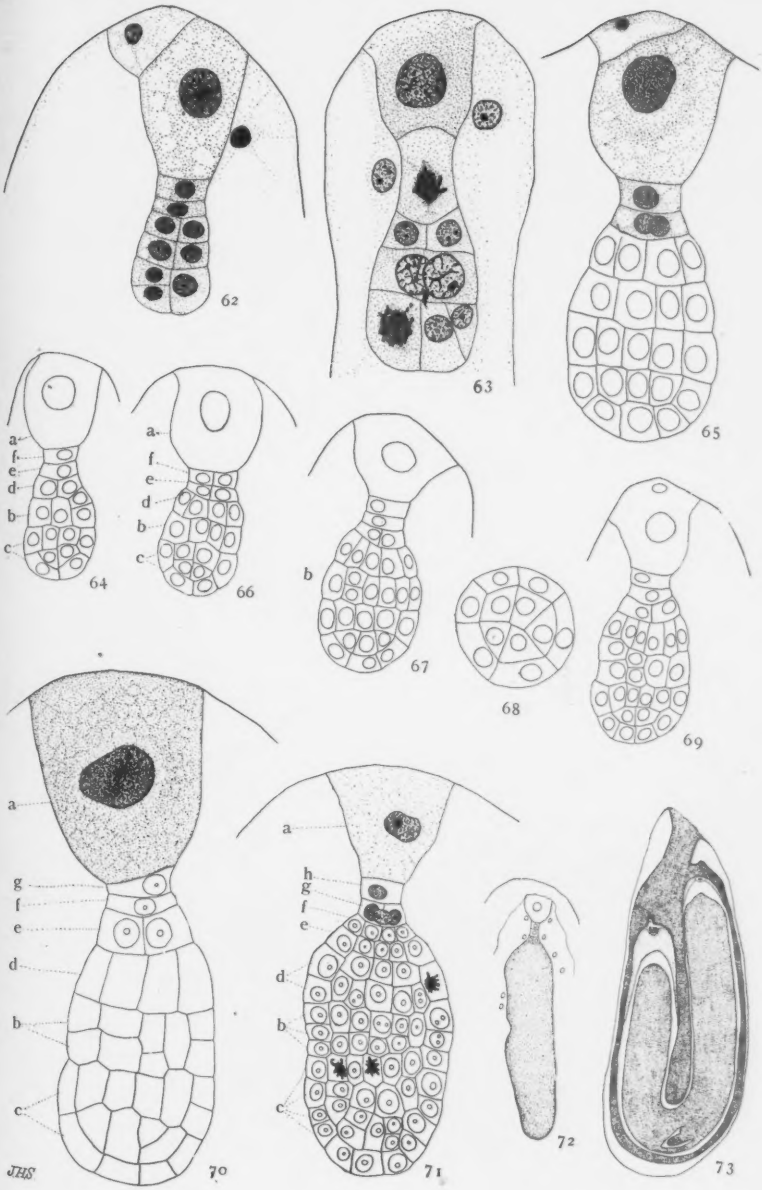
SCHAFFNER on SAGITTARIA VARIABILIS.



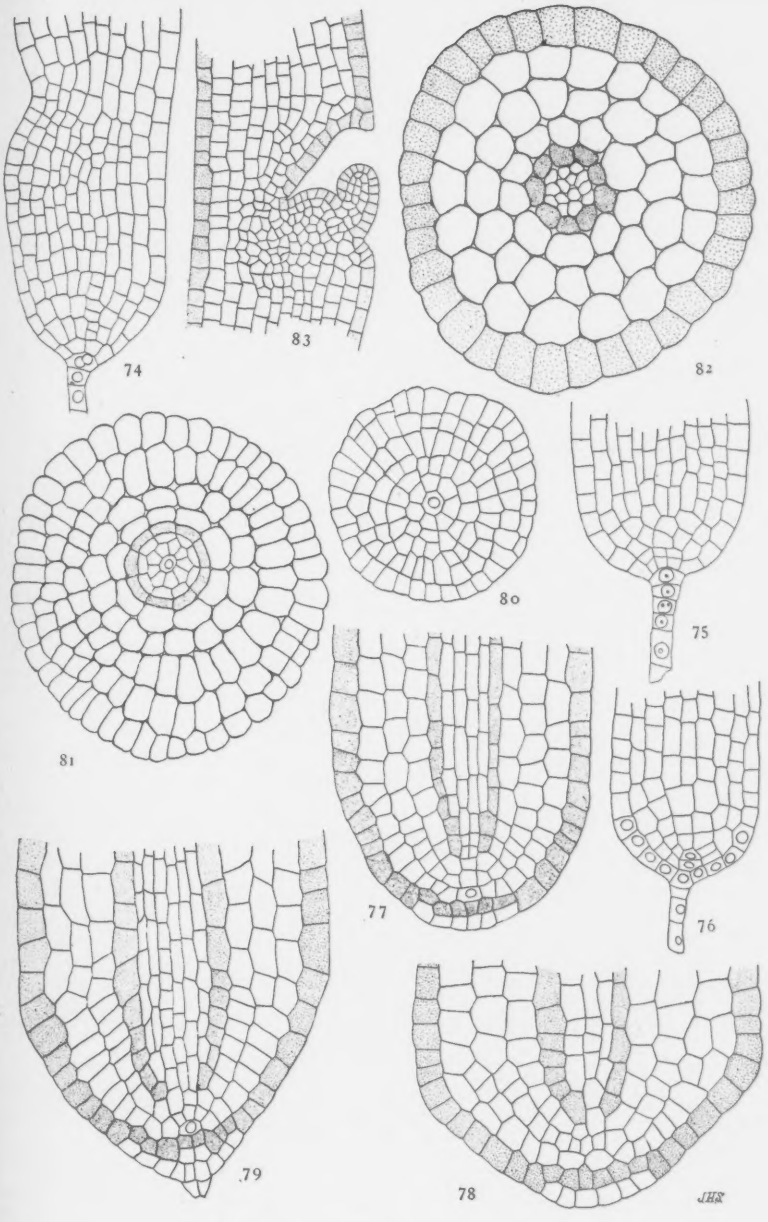
SCHAFFNER on SAGITTARIA VARIABILIS.



SCHAFFNER on SAGITTARIA VARIABILIS.



SCHAFFNER on SAGITTARIA VARIABILIS.



SCHAFFNER on SAGITTARIA VARIABILIS.

FIG. 66. Embryo showing exceptional suspensor development; the cells below the vesicular cell have divided longitudinally. × 260.

FIG. 67. Embryo showing origin of the stem apex by transverse division of a hypodermal cell in tier *b*. × 260.

FIG. 68. Transverse section through the young cotyledon of an embryo at the same stage as *fig. 67*. × 400.

FIG. 69. Embryo showing further differentiation in the development of the stem tip by transverse division of the dermal cell. × 260.

FIG. 70. Embryo a little older than *fig. 69*, showing the glandular appearance of the vesicular cell *a*. × 400.

FIG. 71. Embryo showing further development of the cotyledon (*c*), stem apex (*b*), and hypocotyl (*d*). × 260.

FIG. 72. Embryo more advanced, with two suspensor cells below the vesicular cell. × 66.

FIG. 73. Section of mature ovule showing the position of the embryo, the cap of endosperm beyond the tip of the cotyledon, the fragments of the lower endosperm cells, and the original antipodal region projecting beyond the embryo sac somewhat like a vermiform appendix. × 26.

PLATE XXVI.

FIG. 74. Part of an embryo, showing the beginning of the differentiation of the apex of the root. × 216.

FIG. 75. Root tip of an embryo showing a suspensor with more than five cells. × 260.

FIG. 76. Section of the root tip of an embryo showing the differentiation of a single hypodermal cell into an initial cell. × 216.

FIG. 77. Section of root tip showing the distinct differentiation of dermatogen, periblem, plerome, and calyptrogen, and also the initial cell. × 216.

FIG. 78. Section of a root tip about the same stage as *fig. 77*, but with less regularity in the arrangement of the cells. × 216.

FIG. 79. Section of the root tip of a nearly mature embryo, showing the arrangement of the tissues. × 216.

FIG. 80. Transverse section through the apex of the root of a mature embryo, showing the single initial cell at the growing point. × 216.

FIG. 81. Transverse section a little beyond that shown in *fig. 80*, showing differentiation of the plerome cylinder. × 216.

FIG. 82. Transverse section through the hypocotyl, showing the arrangement of the dermatogen, periblem, and plerome. × 216.

FIG. 83. Longitudinal section through the apex of the stem in a mature embryo. × 140.

PRELIMINARY REVISION OF THE NORTH AMERICAN SPECIES OF CHRYSOSPLENIUM.[1]

J. N. Rose.

Four species of Chrysosplenium are here recognized as belonging to North America. One of these, although it has been long represented in our larger herbaria, has never before been published; another (*C. tetrandrum*) has been considered a variety of *C. alternifolium* by recent monographers. After the examination of much material I have been forced to restore it to specific rank. The name *C. glechomaefolium* of Nuttall must give place to the older varietal name *Scouleri* of Hooker.

The genus is naturally separated into two groups by the leaves, one having them opposite and the other alternate. In America we have two species in each group; of the opposite-leaved group one species is western and one eastern; of the alternate leaved group one species is known only from the Pribilof islands, while the other is high northern, but extends in the Rocky mountains as far south as Colorado, with an isolated form or variety in Iowa.

Although not found in America, *C. alternifolium* is included in the subjoined key on account of its confusion with *C. tetrandrum*.

* *Leaves all alternate.*

+ *Rootstock wanting: stolons slender: flowers yellow: disk inconspicuous or wanting: seeds many.*

++ *Stamens 8: leaves large, dull, veined, thin, spotted.*

Chrysosplenium alternifolium L. Sp. 1:398. 1753.

Stems 5 to 15^{cm} high, 1 to 3-leaved: leaves thin, veined; radical leaves reniform, cordate at base, the sinus often closed,

[1] Published by permission of the Acting Assistant Secretary, Smithsonian Institution, in charge of the U. S. National Museum.

15 to 36^{mm} wide, crenations 6 to 15, sometimes overlapping, broad and truncate or retuse, dull above, pale beneath: cells of leaves and calyx generally developing brown bodies giving the appearance of pellucid dots: stamens 8: seeds indefinite.

Europe and Asia.

++ ++ *Stamens 4: leaves minute, shining, indistinctly veined, not spotted.*

CHRYSOSPLENIUM TETRANDRUM Fries, Bot. Notis. 193. 1858.

Chrysosplenium alternifolium tetrandrum Lund, Bull. Acad. Sci. St. Petersb. 23: 343. 1877.

Stems 1.2 to 7.5^{cm} high, very slender, 1 to 3-leaved: leaves thickish, with indistinct veins; radical leaves very small, 4 to 11^{mm} wide, crenations 3 to 7, more or less rounded, shining above, paler beneath: cells of leaves developing no dark bodies: stamens 4, opposite the sepals: seeds small, numerous (sometimes 50 or more).

Arctic regions. In America as far south as Colorado.

In the United States there are only two stations recorded for this species. One of these is in Colorado, where the plant was collected by Hall and Harbour in 1862 (no. 576). The plant, curiously enough, has not been found since. The other locality is at Decorah, Iowa, where it has been collected a number of times by Professor E. W. D. Holway. This latter form may yet prove distinct. It is somewhat larger, with slightly different leaves, and with six or seven stamens.

+ + *Rootstock thick: stolons wanting: flowers reddish: disk prominent: seeds few.*

Chrysosplenium Beringianum Rose, sp. nov.

Rootstock 2.5 to 5^{cm} long (?), creeping, sending off many long fibrous roots; radical leaves and stems several, spreading and forming a dense rosette: radical leaves small; petiole slender, 1.3 to 4.5^{cm} long, broader at base, the margins (especially below) ciliate with long purplish hairs; blade reniform, 6 to 11^{mm} broad, 4 to 5-crenate, crenations sometimes gland-tipped, thickish, pale and glabrous below, dark green and glabrous or somewhat pilose above: stem 2.5 to 5^{cm} high, naked or bearing a single leaf below the involucre; involucral leaves

several, entire or 3-crenate, extending beyond the flowers: calyx 5 to 6^{mm} broad, 4-lobed, purplish or becoming so; sepals very broad, nearly orbicular, rounded at apex; disk very prominent, strongly 8-lobed; fruiting calyx turbinate, 1^{mm} high: capsule 2-horned, 6 to 10-seeded; seeds oblong, 0.5^{mm} long, shining, delicately reticulated.

Collected by C. Hart Merriam on St Paul Island, August 7, 1891, and described in the Proceedings of the Biological Society without specific name; since collected on the same island by Mr. F. W. True and D. W. Prentiss, Jr., August 6, 1895 (no. 66), and by Mr. James M. Macoun, July 6, 1892, and 1896; subsequently by Mr. Beaman on St. Paul, and one specimen by Dr. Dall in "Alaska."

This species has been confused with *C. alternifolium*, from which it appears to be abundantly distinct. *C. alternifolium* differs in its habit in lacking the thickish rootstocks and possessing only slender stolons and filiform roots; in its larger, usually much larger leaves, more numerous and generally double crenations, the smaller indentations containing a gland, or when simply crenate each crenation gland-tipped, thin, membranaceous in texture (when dry), paler in color; petioles with margins usually glabrous but sometimes ciliate with a few white hairs.

Our form, which resembles *C. tetrandrum* in the size and shape of the leaves, has 8 stamens instead of 4, purple instead of greenish flowers, larger and definite seeds (6 to 10 instead of 30 to 50), stronger-lobed disk, and apparently differs also in its habit.

In the study of this species I have had all the material from the Gray Herbarium, Columbia College Herbarium, Herbarium of the Natural History Survey of Canada, Herbarium of the Philadelphia Academy of Science, and National Herbarium. I also sent specimens to Kew and received the assurance that it "differs from everything else at Kew." Mr. James M. Macoun has also studied it in connection with the material at Kew and the British Museum, but finds nothing like it.

This species will be redescribed and figured in the forthcoming Catalogue of the Plants of the Pribilof Islands by Mr. James Macoun, which will appear in the formal report of the Fur Seal Commission now in press.

* * *Lower leaves all opposite.*

+ *Leaves orbicular, abruptly petioled, with few coarse crenations: flowers sessile or nearly so: eastern.*

CHRYSOSPLENIUM AMERICANUM Schwein. Hook. Fl. Bor. Am. 1:242. 1834.

Canada and Minnesota southward.

++ *Leaves orbicular, more or less cuneate at base, strongly and abundantly crenate: flowers clearly pedicelled: western.*

Chrysosplenium Scouleri (Hook.) Rose.

Chrysosplenium oppositifolium Scouleri Hook. Fl. Bor. Amer. 1:242. 1834.

Chrysosplenium glechomaefolium Nutt. in Torr. & Gr. Fl. 1:589. 1840.

Oregon and Washington.

U. S. NATIONAL MUSEUM.

BRIEFER ARTICLES.

FACILITIES FOR BOTANICAL RESEARCH AT THE NAPLES ZOOLOGICAL STATION.

(WITH PLATE XXVII)

IT was my good fortune to be able to occupy the Smithsonian table at the Naples Zoological Station for three months during the spring of 1896.[1] I had received some time before a printed circular from the director, Professor Dohrn, telling what apparatus I would need to bring and how best to bring it, and in accordance with the wish therein expressed I had written the station stating when I should arrive and what algæ I should desire for study. On the morning of my arrival I visited the station, introduced myself, and found a room prepared for me, with several trays full of interesting algæ on the table. I was put in care of an employé, who helped me to find suitable lodgings, and within three hours I had my baggage moved into them and was installed ready for work in my laboratory at the station. The common reagents for microscopic work had been placed on my table, and such special fixatives and stains as I needed were promptly prepared for me by the chemist in charge of supplies. As I expected to do cytological work I asked for a paraffin oven, which was at once installed. Wall tables, a microscopic work desk, and aquaria were ready, and within two days I had various species of algæ growing vigorously. Almost every want of the investigator is anticipated and provided for. Servants are ready to assist in any heavy work, keep the fire going when the weather is chilly, and clean up the room at night. The abundant and varied facilities for collecting, ranging from a diving suit (found very useful by Berthold in his studies on the distribution of algæ in the gulf) to a small steam yacht, the "Johannes Müller," are at the disposal of the investigator. Cav. Lo Bianco, whose beautiful museum specimens are widely known, has an incredi-

[1] I wish here to thank Secretary S. P. Langley and the committee in charge of appointments to the Naples table for this privilege.

bly wide knowledge of forms and is always ready to assist in procuring any desired species. The library, very rich in zoological and general biological works, is well indexed and is open every day until six p. m. The station buildings, open until nine p. m., are beautiful three-story white structures. On the ground floor of the main building is the unrivaled aquarium, which is of great interest to all tourists, rich as

FIG. 1. View of the Naples Zoological Station from the southwest.

the city is in other attractions. The cut here given (*fig. 1*) shows a view from the southwest. The alcoves along the south side of the library may be seen to the right. The three large windows in the middle of the west front are those of the botanical rooms.

The flora and fauna of the gulf of Naples are exceedingly rich and many of the best collecting grounds for the botanist are close at hand. The whole region is surpassingly beautiful and historically one of the most interesting spots in the world. Occasional cruises on the steam yacht or excursions into the country round about give the investigator a chance to combine his collecting work with the most pleasurable of outings. Of the uniform courtesy and liberality of the director, Professor Dohrn, and his assistants, Professors Paul Meyer and Hugo Eisig, as well as other members of the staff, there is no need here to speak.

The advantages enumerated above are, however, already known to any who may happen to have read the reports of the zoologists on their stay there. It is more particularly to another side of the institution, which has not, I am sure, received the attention it deserves from American botanists, that I wish to allude.

Although known officially as the Zoological Station of Naples, the director has from the first recognized the importance of a knowledge of the flora of the Gulf; as many as three volumes of the magnificent *Fauna und Flora des Golfs von Neapel* relate to algæ, and in the *Mittheilungen aus der Zoologischen Station zu Neapel* there are a number of valuable papers on marine plants by Schmitz, Berthold, Falkenberg, and others.

Of still more importance is the fact that in the recently erected west wing of the station building there is a suite of laboratories[2]

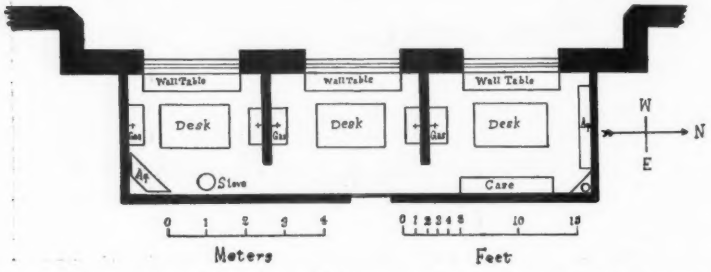


FIG. 2. Ground plan of the botanical laboratories of the Naples Zoological Station.

expressly set aside for botanical work. The ground plan of these rooms is given in *fig. 2*.

Hansen[3] has already described the rooms briefly and enumerated the fairly good set of physiological apparatus belonging to them, so I need only state that inasmuch as through the liberality of the American Society of Naturalists two good microtomes are furnished for the use of the incumbents of American tables, and as the station furnishes small but extremely convenient paraffin ovens, cytological and morphological research is as well provided for as is physiological.

[2] They are behind the three large windows shown in *fig. 1*, and are to be seen also in *Plate XXVII.*

[3] HANSEN, A.: Bericht über die neuen botanischen Arbeitsräume in der zoologischen Station zu Neapel, Bot. Zeit. **50**: 279-285. 29 Ap. 1892. Reprinted with a few changes in Mittheilungen aus d. Zool. Stat. zu Neap. **10**: 654-658. 1 Ap. 1893.

The library, although mainly zoological, has many sets of periodicals containing botanical articles, and possesses in addition about three hundred and fifty volumes exclusively on botany, many of them being very costly illustrated works on marine algæ, and also over seventy-five volumes of botanical reprints and author's copies containing on an average about ten articles each.

There is a very full alcoholic collection of the marine algæ prepared by Berthold and a fairly good local herbarium, which in connection with Berthold's valuable list and sketch of the geographical distribution[4] render it easy, even for beginners in the study of marine flora, to become acquainted with the common forms and to obtain any desired species. The importance of such facilities for those making only a short stay is obvious.

So far, although about thirty-five botanists have worked at the station, many of them at several different times, only three Americans are among the number, namely Dr. H. L. Russell, who worked on bacterial flora of the gulf[5]; Mr. D. G. Fairchild, who studied karyokinesis in Valonia[6]; and the writer, who worked on the cytology of the Sphacelariaceæ.[7] Among other European botanists who have visited the station might be mentioned Goebel, Solms-Laubach, Schmitz, Berthold, Falkenberg, Meyer, Hansen, Fischer, Ambronn, Noll, Went, Valiante, Reinke, Klebs, Famintzin, Golenkin, Klemm, Oltmanns, Benecke.

It should be stated that a table costs five hundred dollars a year, and that at present there are but two supported in this country, one by the Smithsonian Institution and the other by Columbia University. If the splendid facilities for algological work were more generally known I believe that American botanists could easily use at least one table, this too even if, as we all hope, the plans now proposed looking toward the establishment of a tropical botanical station in America can be carried out, for probably there will always be Americans either studying or traveling in Europe to whom the opportunity of spending even a few months at Naples would be very welcome, especially since

[4] BERTHOLD, G.: Ueber die Vertheilung der Algen im Golf von Neapel nebst einem Verzeichniss der bisher daselbst beobachteten Arten: Mittheilungen aus d. Zool. Stat. zu Neap. **3**: 393-536. Tab. 1–3. 1882.

[5] RUSSELL, H. L.: BOT. GAZ. **17**: 312-321. Oct. 1892.

[6] FAIRCHILD, D. G.: Berichte d. deut. bot. Ges. **12**: 331-338. *pl. 21.* 1894.

[7] SWINGLE, W. T.: Jahrbücher f. wiss. Bot. *ined.*

there are many interesting forms growing there which do not occur in the waters of the New World.—WALTER T. SWINGLE, *Washington, D. C.*

EXPLANATION OF PLATE XXVII.

A view of Naples and Vesuvius, looking east from the summit of the Vomero, an encircling range of hills several hundred feet high. In the midst of the park which extends along the shore may be seen the buildings of the Zoological Station.

BOTRYCHIUM TERNATUM SWARTZ, VAR. LUNARIOIDES (MICHX.) MILDE.[1]

(OSMUNDA BITERNATA Lamarck; B. BITERNATUM Underwood.)

I OFFER the following criticism for two reasons; first, because I cannot agree with Dr. Underwood in his attempt to reinstate Lamarck's species on characters so unreliable as those which he brings forward in his article on the "Rarer Ferns in Alabama;"[2] and second, because I consider it an error to credit Professor Eaton with Milde's combination, as he had nothing whatever to do with it. Again, Dr. Underwood is in error in saying that Professor Eaton "overlooked its very distinct leaf and bud characters"; on the contrary those characters were very carefully considered by Professor Eaton at the time he elaborated the species for his *Ferns of North America*. It was my privilege to be permitted to assist Professor Eaton on that portion of his work, and it was through my finding the Georgia specimen of true *lunarioides* in the Gray Herbarium that he was led to change his original treatment of the species. From this it will be seen that the character of the "leaf and bud" were well known to Professor Eaton and had received proper consideration.

But let us take up, one by one, all of the characters brought forward by Dr. Underwood, and see to what real importance they are entitled.

First, as to the character of the bud. He correctly states that "*B. ternatum* is characterized by its hairy bud," but when he adds "while the bud of *B. biternatum* is smooth," the statement requires some qualification, for in all of the specimens of *lunarioides* in my own private

[1] Read before the New England Botanical Club, April 2, 1897.

[2] BOT. GAZ. 22: 407. 1896.

NAPLES and the ZOÖLOGICAL STATION.

collection, and in those in the Davenport Herbarium (Mass. Hort. Soc.), the bud is pilose, and this was true also of the duplicates which I distributed some years ago. Of what value then is an occasional smooth bud except to show that here, as elsewhere, mere pubescence is a variable and unreliable character of no specific importance whatever? The fact is that a similar difference of degree exists in the vestiture of the buds of *B. ternatum* and its var. *lunarioides* as that which exists between the buds of *B. Virginianum* and its var. *gracile*, and we might with equal force contend for the reestablishment of Pursh's species on this ground. In large forms of *B. Virginianum* the bud is usually very shaggy, while in the small forms it is apt to be scantily clothed, and sometimes quite smooth. A similar variation may be found in the buds of *B. ternatum* and its many forms, some being very shaggy, others less so, or only sparingly clothed, or even, as in my specimens from Sweden, nearly smooth. This, it seems to me, effectually disposes of any argument based on the mere presence or absence of pubescence on the bud.

Second, as to "its very distinct leaf." New England botanists who have collected *ternatum* in any quantity know very well that the different varieties merge into one another by almost imperceptible gradations through a great variety of forms, nearly all of which may be found in a series of specimens of the var. *dissectum* alone, thus showing that the mere cutting of the lamina and its consequent differently shaped segments has no specific importance whatever as a basis for separation. Even in individual plants, where the frond of a previous year's growth remains attached, marked differences in the form of the divisions may be found, and I have three fronds taken from one plant in different years that might be taken for different plants by any one not knowing their origin. There are also marked differences in the ultimate segments of individual plants of *lunarioides* itself. I doubt if anyone has seen, or has had pass through his hands, a greater number of these plants, or from a wider range than I have during the past twenty years, and I greatly prefer the comprehensive treatment which Milde gave to this species to any treatment that would break it up into as many species as there are forms. I recognize certain centers of variation, to one or the other of which the different forms can be referred, but it is not possible to separate them into distinct species, as Prantl has attempted to do, without incurring the risk of endless confusion.

Third, as to the relative position of the sterile and fertile divisions

of the frond. An examination of a large suite of specimens of *ternatum* and its forms, from a range extending throughout New England, Canada, Alaska, Washington, California, and Mexico, as well as Georgia, South Carolina, Florida, Virginia, and the Middle States, shows that the length of the stalk of the sterile division of the frond is no less variable than are the other characters mentioned, and varies all the way from one-half an inch to six or eight inches or more. In plants from Alaska and Washington, the stalk is generally very short, sometimes not over three-eighths of an inch long, while in a specimen of true *lunarioides* from Florida (*Chapman*) in the Gray Herbarium the stalk is three-fourths of an inch long, and it is more than probable that if we could get as large a number of specimens of *lunarioides* as we do of the other forms we should find an equal degree of variation in the length of the stalk. Dr. Milde's tables of measurements for the different forms of this species show how extremely variable and unreliable this character is.

Fourth, as to its habitat, concerning which little need be said. It is not an uncommon thing to find typical *ternatum* growing in dry soil on high ground as well as in low moist woodlands and swamps. Only last August (1896) I found a fine plant of it growing on a very shallow grassy knoll on top of a granite ledge!

Fifth, as to the spores, the most important of all characters in the botrychiums. Here, as elsewhere, I fail to find any differences to justify specific recognition. An examination of the spores from my Alabama and European specimens shows less difference between the spores of these two forms from such widely separated regions than there is between the spores of the individual plants themselves. In fact they are identical in shape and marking. Neither can I detect any marked distinction between the spores of plants from New England, Canada, Alaska, Washington, California, and Mexico. On the contrary, in all of the forms of *ternatum* which I have examined, the spores of individual plants vary in shape, some being reniform, some pyriform, others oval or egg-shaped, and some even with irregular curved outlines, but the markings appear uniformly the same in all. My examinations have been made with a Leitz $\frac{1}{12}$ immersion objective, and the result shows conclusively that absolutely one type of spore runs through all forms of *ternatum*.

Sixth, concerning the time of perfecting spores, unfortunately, the evidence is incomplete, as we have no knowledge of the fruiting time

of *lunarioides* in its more northern latitude. There are, however, some data bearing on the question that lead me to believe that the early fruiting of Alabama plants may be explained naturally without resorting to specific recognition. Milde credits *lunarioides* to Lake Superior (*Macoun*) and Montreal (*Watt*) in Canada, and I cannot believe it possible for him to have been mistaken in any specimens coming under his personal observation. Dr. Watt's specimens I have not seen, but I do not find any true *lunarioides* among the plants which Professor Macoun has very kindly sent to me for examination. His specimens are nearly all identical with the European *rutaceum*, but I am of the opinion that he must have sent *lunarioides* to Milde at some time, or the latter would not have vouched for it. It is not improbable, therefore, that if we had more reliable data it would be found that *lunarioides* in a more northern latitude would mature spores well on into June or July. One thing is certain, however, and that is that the fruiting time of *ternatum* and its forms, throughout its northern latitudes, ranges all the way from June to October, and it is not surprising that in tropical or semitropical climates its range should begin earlier and last longer. It is certain also that a difference of time exists even in the same latitudes between different and even the same forms according to the situations in which they grow. Thus, on Mt. Desert, according to Mr. Rand, normal *ternatum* growing on mountain tops perfects spores in July, while in the woodland swamps at the base of the same mountains it does not mature spores until late in September. In 1879 Dr. Charles Mohr very kindly sent to me a generous supply of *lunarioides*, at the same time calling my attention to its early fruiting, his specimens being collected in March, and the matter was fully considered by Professor Eaton and myself, with the conclusion that this was not in itself of more than varietal importance, and that Milde's disposition of the plant was correct. Nearly all of the specimens which I received from Dr. Mohr had a frond of an earlier growth remaining, and the weather beaten fertile panicle of the older frond had discharged all of its spores, while the panicles on the fresh fronds were only partially developed and the sporangia were immature, and now look as if they would not have been ready to discharge spores for some time longer, perhaps not until well into April; certainly not very remarkable for a southern species that in the north sometimes matures spores in June! On this point Dr. Mohr writes me that the Alabama season extends from January to the middle of April.

But even conceding the importance claimed for this habit of early fruiting, it is still only one point of six left open for consideration, and we may sum up all the characters of *lunarioides* that we have been reviewing as follows:

1. *The bud:* Commonly pubescent, of varying degrees, only rarely smooth; character not of specific value.

2. *The lamina:* Its cutting and shape of the segments; character wholly unreliable, or of varietal importance only.

3. *Relative position of the sterile and fertile divisions:* Sterile division nearly sessile, or short-stalked; scarcely of more than varietal significance.

4. *Habitat:* Character variable and unimportant.

5. *Spores:* Shapes and markings as in the other forms (including type); no specific differences.

6. *Fruiting time:* Evidence incomplete and inconclusive, and doubtfully of more than varietal significance at the most.

My conclusion, therefore, is that Lamarck's *Osmunda biternata* had best remain where Milde placed it, under *B. ternatum* as a good variety.

But here arises another question which it may be well to consider briefly. There is a tendency on the part of some of our later authorities to give to well marked varieties specific recognition, on the ground that it facilitates scientific investigation; and since, at the best, species are merely the arbitrary definitions devised by man for the convenience of study, there would be no serious objection to this if it were not for the numerous intermediate forms that constantly confront us and demand recognition. It is all very well to say that such forms may be disregarded for purposes of classification, but we cannot dispose of them in that way. They are an essential part of Nature's great scheme of evolution, and just as much entitled to recognition as more definite forms. I have known collectors who were in the habit of throwing to one side all puzzling forms that could not be placed readily, so as not to disturb the arrangement of species in their collections, but no close student of nature would be content with such practices. Nature shows little sympathy for our conceptions of species; she deals with large groups, orders, races, and the nearer we approach to her methods the more accurate will our knowledge of her great works become. It is for this reason, therefore, that I prefer that broader recognition of the

limitations of a species which provides for all intergrading forms and their variations.

A list of the material used in my examinations may be of interest, as showing the extensive range and cosmopolitan character of this species.

1. Specimens, including all forms, from various parts of New England, from my own collections and those of John Robinson, Walter Deane, Mr. Pringle, and others; beside which I have had access at various times to the fine collections of Professor Eaton, Mr. Faxon, and the especially valuable collection (now in possession of the Appalachian Mountain Club) of the late Mr. E. H. Hitchings; to say nothing of the numerous specimens which I have identified, from time to time, for various collectors and correspondents.

2. Specimens from New York and the Middle States, from the collections of Mrs. Barnes, Rust, Myers, Gifford, and other members of the Syracuse Botanical Club; also collections of E. S. Miller (Long Island), J. H. Redfield (Pennsylvania), Dr. Schneck (Illinois), and others. One of Mrs. Barnes' North Woods plants is remarkable for the small, rounded, almost lunate segments (as in Alabama plants), and the very nearly sessile sterile divisions, the stalk of which is shorter than in Chapman's Florida specimen. Between this and her larger plants, that approximate Californian *australe*, there is every conceivable variation.

3. Specimens from Canada: Prince Edwards Island, north shore of Lake Superior, Northwest Territory and British Columbia, from the collections of Professor Macoun.

4. Specimens from Alaska (*Turner*), Washington (*Suksdorf*), California (*Miller*), and Mexico (*Pringle*).

5. Specimens of *lunarioides* from Georgia (original specimen figured in Eaton's *Ferns of North America*), in Gray Herb.; Florida (*Chapman*, in Gray Herb.); South Carolina, in Herb. Mass. Hort. Soc., donated by Redfield; Alabama, in Herb. Mass. Hort. Soc. and my private collection, from Dr. Mohr. In all of these specimens the bud is pilose.

6. Specimens from New Zealand, in Gray Herb.; Japan (*Oldham*, and a specimen collected by Ångström), in Gray Herb.; also specimens from Sweden in my own collection.—GEORGE E. DAVENPORT, *Medford, Mass.*

SEED CRESTS AND MYRMECOPHILOUS DISSEMINATION IN CERTAIN PLANTS.

A NUMBER of common plants have seeds with whitish fleshy appendages, varying in form and in the extent of attachment to the seed, but at most hardly forming more than a ridge on one side.

In those plants in which dissemination is effected by mammals or birds which swallow the fruit, the fleshy coat completely covers the seed, at least in the ordinary cases, and we would hardly expect these creatures to be attracted by appendages of the limited size of ordinary seed crests. On the other hand, there seems to be no improbability of their being attractive to ants, and they form a very convenient handle by which the ants may seize and carry away the seeds.

A long time ago I noticed that a follicle of *Sanguinaria Canadensis* had dropped its seeds in a cluster upon the ground. Returning to the spot a short time after I was surprised to find that all of the seeds were gone except one in the clutches of an ant which had already dragged it a few feet away. This case was reported verbally to Professor Trelease and was mentioned by him in a paper on myrmecophilism.[1] Since that time I have frequently exposed seeds of Sanguinaria in situations frequented by ants and have observed that these insects invariably seize the seeds and carry them away. On another occasion the contents of several fruits of *Sanguinaria Canadensis*, *Uvularia grandiflora*, and *Trillium recurvatum* were placed in a run frequented by *Formica fusca*, and it was observed that all of the seeds were carried away in about an hour.

The supposition that the plants depend upon the crests for dissemination is strengthened if it can be shown that they have no other means of seed dispersal. In Sanguinaria the follicles remain erect or fall over upon the ground. In either case the seeds are turned out upon the ground without being scattered. In *Erythronium albidum*, which has similarly crested seeds, the capsule bends the scape down so that, when it opens, the seeds roll out.

At first the case of *Uvularia grandiflora* seemed opposed to the supposition, for I was aware of the fact that, while the flowers were pendulous, the position of the capsules was different. This suggested the familiar case in which the flowers are pendulous, but the seeds are finally held in an upright basket where they are retained until a jost-

[1] Psyche —: 179. 1889.

ling of the plant is likely to throw them to a considerable distance. When this Uvularia is in bloom the leaves are flaccid and pendulous. Later, however, when the leaf through which the peduncle passes becomes rigid and horizontal, the stalk changes its position, but only enough to get out of the way of the leaf. At dehiscence the axis of the capsule is directed horizontally, its valves become strongly reflexed, and the seeds fall out upon the ground.— CHARLES ROBERTSON, *Carlinville, Ill.*

EDITORIALS.

In connection with the nomenclature question, which is proving to be one of great difficulty, it may be well to consider the subject of describing new species. It is a fascinating employment, but, like many fascinating things, has its dangers. That plants must be classified and properly named no one will question, and that this work is very far from completion is no less evident. The proper classification of a form, however, is based upon facts very different from those thought adequate when taxonomy was almost the only phase of botany. In those days, the classification was confessedly artificial, the purpose being little more than a convenient cataloguing of forms. In these days, however, classification is based upon genetic relationships as indicated by a careful study of morphology. As a consequence, those courses of instruction which are logical permit no independent taxonomic work except as a sequence of morphological investigation.

New Species

The higher groups, perhaps, present the least difficulty in determining the general relationships of a form; so that the details of its morphology may not be necessary. But even here such a knowledge of the morphology of the group, and of its habits of variation, is essential as can come only from what is called, for convenience, its monographic study. In view of the immense difficulties of synonymy it would seem wise to reduce taxonomic publication within the limits of reasonable certainty.

In the lower forms, however, and especially in the case of those which are polymorphic, such as many parasitic fungi, hasty taxonomic publication becomes almost inexcusable. One can imagine no more hopeless tangle of synonymy and relationship than that presented by the average list of "new species" dealing with such forms, in which the characters are drawn from form and size, without any knowledge of life history and power of variation. If a botanical congress could devise some code for the suppression or restriction of "new species," it would help towards the application of a code for nomenclature.

OPEN LETTERS.

THE TROPICAL LABORATORY COMMISSION.

To the Editors of the Botanical Gazette:— Dr. J. E. Humphrey, accompanied by a number of advanced students in zoology from Johns Hopkins University, will carry on some investigations in the vicinity of Port Antonio, Jamaica, during the ensuing season, and he has kindly agreed to cooperate with the commission in the examination of that island. His previous experience in Jamaica will enable him to render the commission important and valuable aid.

In the arrangement of plans for the work of the commission, provision will be made for a repetition of a portion of the tour of investigation during the coming winter, in order to appreciate more fully the climatic possibilities of the more promising localities. This will, of course, slightly delay the final selection of a site, but not the organization of the laboratory.

The following quotation from the *Journal of Botany* for March will serve to illustrate the attitude of the British botanists in the matter:

"A botanical laboratory in the western tropics has long been greatly needed, and we have much pleasure in announcing that the establishment of such an institution is completely assured. . . . . It is believed that cordial cooperation on the part of botanists of this country would be welcomed. In order to secure this cooperation we venture to recommend one of the Lesser Antilles as the site. These islands are only a fortnight from London, and their botanical attractions for future work are great. . . . . A site in Mexico, for example, though much to be recommended on other grounds, would be a hindrance to cooperation on the part of botanists in this country on account of the length of the journey. We heartily congratulate American botanists on this manifestation of their enterprise, and wish it the success it undoubtedly deserves."— D. T. MACDOUGAL, *University of Minnesota.*

CURRENT LITERATURE.

BOOK REVIEWS.

The abnormal formation of resin ducts.[1]

Dr. Alexander P. Anderson has distributed separates of his thesis presented to the faculty of the University of Munich for the degree of doctor of philosophy. The paper contains interesting matter for botanists, pharmacists, and foresters. A careful perusal of it however, leaves the impression that a large number of more or less interesting facts are here brought together, but without proper assimilation. This may be unavoidable because so little is known of the subject, too little to permit at this time any generalizations; for before the appearance of this paper little had been published upon the matter, the references to it being mostly incidental.

Resin ducts occur normally in the wood of spruces, pines, and larches, and are normally wanting in the wood of balsams, hemlocks, and cypresses. Wood parenchyma (simple resin receptacles, Göpp), according to Krause is present in the wood of all species of Abies. Hartig found a marked irregularity in the number and distribution of resin ducts in certain conifers that had been attacked by *Agaricus melleus*. He also found that in spruces in which so-called double rings were formed on account of late frosts, there is a striking irregularity in the formation of resin ducts in such rings. In 1892 J. Hortman made some comparative anatomical investigations on the shoots from a "witch broom" on *Abies pectinata* and the normal shoots of the same species, in which he found that in the abnormal formation of cortex there is great irregularity in the structure and in the size, as well as a considerable increase in the number of resin receptacles. E. Mer found an abnormal formation of resin ducts in shoots of Abies sp.? as a result of the attacks of *Phoma abietina*.

We must assume that abnormal resin receptacles are present only when the plant is in part or entirely pathologically influenced. If for example resin reservoirs be found in the wood of *Abies pectinata*, they are a sure indication of some pathological condition existing in the plant. Further, with our present knowledge we must assume that resin is strictly an excretion, being of no further use in the metabolism of the plant.

[1] ANDERSON, ALEXANDER P.— Über abnorme Bildung von Harzbehältern und andere auftretende anatomische Veränderungen im Holze erkrankter Coniferen. Inaug. Diss. Sonderabdruck aus der Forst.-naturw. Zeitsch., 1896. 8vo. pp. 38, *figs.* 7.

Three classes of pathogenic material were used in these investigations: (1) frosted conifers; (2) witch brooms on different species of Abies produced by the growth of *Æcidium elatinum*; and (3) tissues of conifers that had been infected with *Agaricus melleus*, *Phoma abietina*, or *Pestalozzia Hartigii*. In the first case tissues from *Pinus sylvestris*, *Picea excelsa*, and *Chamæcyparis Lawsoniana* were used. When twigs of *P. sylvestris* are frosted but not killed their tissues sometimes lose their power of becoming turgid and the shoots therefore tend to remain in a drooping position. By renewed growth near the tip of the branch the apex again assumes to a greater or less degree an upright position. Where this renewed growth takes place, on the under side of the branch a large amount of the tissue formed is similar to the "red wood" formed on the under side of normal hyponastic branches of *Pinus Strobus* and *Picea excelsa*. In both cases there are fewer resin ducts on the side of the twigs having "red wood" than on the other. "Double rings," or "frost rings," are sometimes formed in the two, three, or four-year-old parts of frosted pine shoots. In such cases there are generally no vertical resin ducts in the inner half of the annual ring. This is true also of *Picea excelsa*. The annual ring, with frost ring, in this species is essentially like that of *Pinus sylvestris* so far as structure, number, and distribution of ducts is concerned. In some instances, where the frost ring is formed late or where two are formed in one season, there may be developed a complete circle of resin ducts in the frost ring itself. Resin ducts are abnormally formed in the bast in twigs of *Chamæcyparis Lawsoniana* as a result of frosting in late spring. The ducts are formed where the cells have been forced apart by the formation of ice masses between them and they have failed to return to their normal position after the melting of the ice.

In the investigations on the "witch brooms" from species of Abies, particularly *A. pectinata* and *A. firma*, tissues of the tumor produced at the original point of infection of the leaf, of the twig and of the buds were employed. The branches of the "broom" on *A. firma* are negatively geotropic, have about twice the diameter of the normal branches and are relatively shorter. The diseased twigs develop very early as do the needles upon them, while the normal ones are much later. The latter are much thicker and about one-half the length of the normal leaves. In *A. firma* the diseased needles do not fall in the autumn, while in *A. pectinata* they do. In both the needles show no transverse heliotropism. The buds are relatively larger than those of normal branches; they have a greater number of scales but these are smaller than in the healthy bud. The resin ducts in the diseased bud scales have the regular form, but they are either abnormally large or abnormally small and have fewer and more irregular epithelial cells than have the normal scales. The mycelium of the fungus penetrates all parts of the tissue except the cavity of the ducts and the epithelial cells. Generally there are fewer stomata and trichomes and a smaller amount of

fibro-vascular tissue than in the normal scale. In the rudimentary leaves and summit of the stem there are neither resin-ducts nor mycelium during the winter. Resin ducts develop earlier in the season in the cortex of the twigs of the "broom" than in normal twigs, and they are always present in greater numbers in the former than in the latter.

In the cortex of the "witch broom" tumor it occasionally happens that the communication by way of resin ducts between the diseased parts above the point of infection and the healthy parts below it is broken. Ducts are never formed in the phloem, while in the wood they are present in every annual ring. The diameter of these ducts and their number are greatest at the middle part of the tumor. From this point toward either end the diameter, number, and number of epithelial cells in each, diminishes. At the lower end all the ducts are pointed and terminate between diseased and normal wood. In the upper extremity all ducts which end with the tumor are pointed. Ducts seem to occur as often in the wood of healthy twigs having their origin above the point of infection as in that of the diseased ones. In the wood of the tumor there is usually, in each annual ring, a circle of ducts and sometimes two such circles.

Tissues of *Picea excelsa*, *Pinus Strobus*, and *Larix Japonica* infected with *Agaricus melleus* show that there is an increase in the number of vertical ducts in the diseased wood ring in all parts of the plant above the point of infection. The greatest increment of wood in the diseased ring is found in the upper part of the plant, from which downward the thickness of the ring decreases. With this decrease in thickness there is a corresponding increase in the number of resin ducts per square unit of section surface. In *Abies pectinata* infected with *Phoma abietina* resin ducts occur only in the healthy wood above the diseased part of the branch. These ducts are similar to those in the wood of the "witch broom" on Abies. Tissues of *Abies pectinata* and *Picea excelsa* infected with *Pestalozzia Hartigii* show in the former the formation of abnormal ducts only in the sound wood above the diseased part of the stem and in the latter the formation of a larger number of ducts in the healthy wood above the diseased part of the stem than is found in normal spruce wood.—L. S. CHENEY.

The sensibility of plants.

PHYSIOLOGISTS are engaged in the effort to bring the phenomena of sensibility of the plant and animal into a system with uniform terminology. One group of writers insist upon the elevation of the forms of sensibility of the plant to the dignity of senses, coordinate with those of the animal. A second group, basing their conclusions upon the reflex nature of the reactions of the plant, see nothing in them beyond highly specialized forms of irritability.

The text of a recent popular address by Dr. Noll is of interest in this connection.[2] The popular superstitions and fanciful theories of the intelligence, spiritual life and sensibility of plants since the time of Empedocles (fifth century B. C.) are brought into review in the light of modern investigation, and following a summary of the results upon which the current theories of irritability are based, the author enters upon a highly metaphorical discussion of the true nature of the sensibility of plants. Defining a sense he says: "The ability to feel the relations of the surrounding world, or objectively expressed, to receive these relations as stimuli, and react by variations in the life processes, is to be designated as sense." Psychologists are not so easily satisfied, however. With such definition as a basis the author proceeds to the statement, "that portions of plants are to be recognized, which not only *can*, but *must* be designated as *sense organs*." To term the pulvinus of Mimosa a specific sense-organ does not attain the advantage of inclusion of similar things under single terms as claimed by the author.

It is to be seen that the greater portion of the paper was not meant to be taken too seriously or literally by the audience to whom it was addressed, for in the concluding paragraphs it is pointed out that the presence of consciousness or of any of the psychic functions of a centrally organized nervous system has not been demonstrated in plants, and therefore that real senses are wanting, since a reflex connection of the motor and sensory zone meets every necessity of existence. Weber's law of the relation of stimulus to reaction, once thought to be a test of the presence of consciousness, has been found to apply to some reactions of plants, but since it is possible to construct a machine which will obey this law, it has lost its significance in this connection.

The author has appended a series of critical notes on the various questions suggested in the lecture. An interesting comparison is made of the greater degree of perfection of the sensibility to gravity in the plant, with the function of the otocyst in lower, and the semi-circular canals of the ear in higher animals. Great importance is attributed to the interprotoplastic threads in the conduction of impulses, though the writer does not seem aware of the fact that the interruptedness of the nervous tissue of animals is universally accepted. In harmony with the work of the reviewer the curvature of tendrils in response to changes in temperature are not regarded as reactions in the same sense as those to contact, etc.

A discussion is given of Czapek's objections to Noll's theory of the irritability of secondary roots, and of Pfeffer's adverse criticisms of certain phases of "heterogene Induktion," but no new facts are adduced. The value of figurative discussions of the nature of the irritability of plants is extremely doubtful. In no part of the subject is it more necessary to keep the feet on

[2] Das Sinnesleben der Pflanze. Sonderabdruck a. d. Ber. u. d. Senkenbergische Naturf. Ges. i. Frankfurt, a M. 1896. Vortrag gehalten 31 Mai, 1896.

solid ground, and advance should be made from fact to fact only. Popular literature is quite full enough of fanciful conceptions of plants without additions from the laboratory.

The entire paper, however, will be interesting reading to that class of biologists who profess to see in plants a series of degraded forms, which began retrogression on the acquisition of the habit of fixation.—D. T. MACDOUGAL.

MINOR NOTICES.

THE CŒUR D'ALENE mountains of Idaho have long been known as interesting botanical ground. All of northern Idaho presents that combination of conditions which has resulted in an unusual flora. During the summer of 1895 Mr. John B. Leiberg undertook a botanical survey of the Cœur d'Alenes, under the direction of the Division of Botany, of the Department of Agriculture. This survey was the more significant and fruitful as Mr. Leiberg had lived in northern Idaho for about ten years, and was already very familiar with the region. A contribution[3] just published gives us some of the results, dealing with matters both biologic and economic, as follows: topography, drainage, climate, mineral deposits, agricultural capacity, agricultural products, grazing lands, native food plants, utilization of water supply, forest resources, forest zones, forest destruction, burned areas, forest preservation, and a new system of timber protection.—J. M. C.

RECENT BULLETINS from the experiment stations embrace a variety of botanical subjects. E. J. Durand (Cornell no. 125) describes a disease of currant canes observed in New York and New Jersey not before noted in this country. Three fungi were found: *Tubercularia vulgaris*, *Nectria cinnabarina* and *Pleonectria berolinensis*, of which the first two are the chief or only cause of the disease, and also are undoubtedly forms of one species. Little was accomplished with cultures and inoculations. A. S. Hitchcock (Kans. no. 62), in thirty-four pages and ten plates, gives much information about two species of corn smut (Ustilago). Successful infection experiments were made. A. D. Selby (Ohio no. 73) briefly describes and illustrates a number of fungous diseases of the forcing house and garden. R. H. Price (Texas no. 39) gives a general account of the peach, including notes of botanical interest on diseases and on the five classes. A popular account of bacteria and their study is presented by C. E. Marshall (Mich. no. 139) in thirty-seven pages. Three troublesome weeds: *Hieracium aurantiacum*, *Daucus Carota* and *Solanum rostratum*, are briefly described by F. L. Harvey (Me. no. 32). Geo. Vestal gives a popular account of the care and handling of seeds (N.

[3] LEIBERG, JOHN B.—General report on a botanical survey of the Cœur d'Alene mountains in Idaho during the summer of 1895. Contrib. Nat. Herb. **5**: 1–85. 1897.

M. no. 20). Attention is called to the value of mushrooms and puffballs for food by L. M. Underwood (Ala. no. 73) in ten pages. Specific description is accorded *Agaricus campestris, Amanita Cæsarea*, said to be common in Alabama, and its poisonous relative *A. muscaria*. A chemical study of the Irish potato by T. L. Watson (Va. nos. 55 and 56) contains some facts of interest to vegetable physiologists.—J. C. A.

NOTES FOR STUDENTS.

MR. THEO. HOLM, in the continuation of his morphological and anatomical studies in the Cyperaceæ, has recently investigated *Carex Fraseri*,[4] a very rare and local sedge with an appearance so peculiar as to distinguish it easily from other species of Carex. His results still further emphasize this distinctness. "The monopodial ramifications of its rhizome, with its single assimilating leaf destitute of sheath, ligule, epidermal expansions and bulliform cells, in connection with its flat and hollow stem, besides the uninterrupted pericambium of the root, constitute a structure that seems almost unique in the family of the Cyperaceæ."—J. M. C.

AN INTERESTING CONTRIBUTION to the subject of rhythm in plants is afforded by L. Jost's recent work on Mimosa.[5] This plant is one of the few known examples in which etiolated leaves are irritable, and which exhibit periodic movements. In the experimental work etiolated leaves were obtained by enclosing the tip of a branch in a dark chamber. The periodic movements of the enclosed etiolated leaves were not induced by impulses from the free leaves, since artificial alterations in the periods of illumination and darkness of the latter produced no variations in the movements of the enclosed organs. The periodic movements of green as well as etiolated leaves of Mimosa are due largely to variations in temperature. Rise in temperature causes the leaves to assume the night position, and a fall in temperature the day position; exactly the reverse of the relations of flowers to temperature. This fact is remarkable in view of the fact that leaves and flowers react alike to changes in the intensity of light.—D. T. MACDOUGAL.

MR. T. CHALKLEY PALMER has succeeded in demonstrating, by a very simple device, that diatoms absorb carbon dioxide and exhale oxygen under the influence of light. While these indications of photosyntax were not needed to prove that diatoms are plants, the simplicity of the device makes the demonstration an easy one to employ in illustrative work. Advantage is taken of the fact that an ordinary aqueous solution of haematoxylin loses its

[4] Am. Jour. Sci. IV. **3**: 121–128. *pl. 4.* 1897.

[5] Ueber die periodischen Bewegungen der Blätter von Mimosa pudica in dunkeln Raume. Bot. Zeit. **55**: 1 Abth. Hft. VI, Feb. 16, 1897.

"normal rosy or slightly bluish-red tint," when exposed to carbon dioxide, and becomes "yellow with a tinge of brown;" and "in the presence of nascent oxygen the light red hue deepens momentarily and ends by becoming a very deep blood red." In a properly guarded test tube a solution of haematoxylin is placed which has been acidified with carbon dioxide. Into the brownish-yellow liquid living diatoms are placed and exposed to bright light. Gas arises, and within fifteen minutes the color has become quite red, continuing to deepen in color until it is blood red. By using two tubes filled with normal reddish solution of haematoxylin, and placing a living snail in one and diatoms in the other, the former pales rapidly under the influence of the carbon dioxide from the snail, while the latter rapidly darkens and reddens. In all cases, of course, other tubes containing the solution are used as checks.—J. M. C.

DR. ANTON HANSGIRG[6] has recently investigated the ability of plolen to resist water, and the relation between this power and the protection against rain and dew. Since many plants whose pollen grains and sporophylls are fully protected against rain and dew have very resistant pollen, and, on the other hand, plants with exposed sporophylls often have pollen very sensitive to moisture, he considers Lidforss' parallelism between protection against rain and the resistance power as questionable. Although the cohering pollen of many plants needs protection against too early wetting, there are many entomophilous plants whose pollen can withstand wetting without injury. In different families and genera there are many intermediate forms between these and those with pollen very sensitive to moisture. The author gives a long list of plants whose pollen germinates well in pure water, but whose sporophylls are not protected against wetting. Another list includes those whose sporophylls are protected against wetting, but whose pollen germinates thoroughly in pure water. Plants whose pollen germinates poorly or not at all in pure water will be noted later, the present paper being a preliminary statement.—C. J. C.

J. M. JANSE has published recently an account of his researches upon root endophytes.[7] He examined forty-four dicotyledons, fourteen monocotyledons, five gymnosperms, and six cryptogams. In these cases the endophyte failed to appear in but one dicotyledon, three monocotyledons, and two cryptogams. The plants studied were taken almost entirely from natural conditions, and many specimens of each type were used in order to avoid exceptional cases. The superficial roots are inhabited more often than the deeper ones. A filament of the fungus forces its way through the epidermis, and usually without branching passes directly through the outer layers of cells. Then the hypha

[6] Zur Biologie des Pollens. Oesterreichische Bot. Zeitschrift **47**: 48–52. 1896.

[7] Ann. Jard. Bot. Buit. **14**: 53–202. 1896.

branches rapidly and invades the tissue longitudinally. In this region of branching many "vesicles" are formed. It is thought that these "vesicles" may be cysts which germinate when they are freed by the disintegration of the root. Usually the fungus penetrates deeper than the region of "vesicles," and forms "sporangioles." These are not reproductive bodies, but disintegrate soon after formation. They are formed within cells only, while the "vesicles" may be either in cells or intercellular spaces. The fungus never penetrates the endodermis, and usually stops with one or two layers of cells separating them. It never enters cells which contain no nutritive substances, and evades scrupulously those which contain such substances as tannin and resin. It seldom enters cells containing chlorophyll; but in a few cases where aerial root cells contained chlorophyll on one side, the endophyte was found to occupy the other side of the same cells. The fungus nourishes itself with the starch grains of the infested cells and those adjacent to them. This loss of starch marks the only possible detrimental effect in the host cells.

The systematic affinities of the endophyte are absolutely unknown, although several authors have described it or some similar form. Jansen claims that none of the forms so described can be the one which he presents. There is variation in the structure of this endophyte in different hosts, but the "guest" seems to maintain its identity sufficiently throughout its various habitations. The slight morphological differences do not necessarily indicate physiological differences.

The author thinks the association of the endophyte with its host one of mutualism ("commensaux"). He likens it to such conditions as exist between Rhizobium and the root tubercles of the Leguminosæ, and *Saccharomyces Kefyr* and *Bacillus Causasicus*. The endophyte evades free oxygen, as is shown by its aversion to chlorophyll cells. The host plant gives it a hiding place, and it is also furnished with food in the form of starch. The nuclei of the host cells in which the "sporangioles" are breaking down become very large and divide rapidly, giving evidence of being well nourished by the nutritive matter of the "sporangioles." The host cells use a large part of the nitrogen compounds of the "guest." Experiments upon coffee plants show that they grow best when their roots are inhabited by the endophyte.—O. W. C.

CENTROSOME LITERATURE has received a notable addition in the recent contribution of R. Lauterborn[8] upon diatoms. Various species of Surirella and Pinnularia form very favorable objects for the study of centrosomes, since these bodies can readily be seen in Surirella even in the living condi-

[8] Untersuchungen über Bau, Kernteilung und Bewegung der Diatomeen: Aus dem zoologischen Institut der Universität Heidelberg. Leipzig, 1896.

tion. The author's investigations on this point are exceedingly interesting. There is one centrosome which lies in a depression beside the resting nucleus. The centrosome appears "naked" in the living condition, no attraction sphere being seen around it. The author agrees with Häcker that the attraction sphere is an artificial structure produced by plasmolytic contraction of the centrosome. While the nucleus is in the resting stage there are no radiations around the centrosome; but when nuclear division begins the centrosome passes out of the depression and becomes surrounded by exceedingly well defined radiations, which appear as definite in the living state as in fixed preparations or more so. There is a close relation between the centrosome and nucleus, which becomes apparent when the nucleus is forcibly removed from the cell. In this case the centrosome remains attached to the nucleus even if all the cytoplasm from both has been torn loose. The fact that the centrosomes, as in Surirella, can be seen plainly in living cells is a strong argument against the temporary organ hypothesis. The centrosome is a kinetic center from which, at the beginning of nuclear division, activities proceed out upon the nucleus and cytoplasm, which appear morphologically as radiations around the centrosome. When the radiations appear a new body arises in close proximity to the centrosome, which is the beginning (*Anlage*) of the central spindle. This body appears to come from the centrosome by division or budding, although the process was not observed. The central spindle body soon increases in size and begins to pass through a series of peculiar forms. It elongates and becomes sheaf shaped, and when the nuclear membrane has disappeared, it enters into the nucleus, and the chromatin segments arrange themselves about its equator and are then carried to the poles. The author has very carefully observed that the central spindle body is not to be confounded with a nucleolus. Before the central spindle enters into the nucleus the centrosome begins to vanish. During the formation of the daughter nuclei a centrosome appears at each end of the central spindle, and when the nucleus is about completed a centrosome lies in the nuclear depression at the central point of the cytoplasmic radiations. At this stage nothing more is to be seen of the constricted ends of the spindle. Their substance is very likely withdrawn into the centrosomes. The origin of the two centrosomes at the poles was not definitely determined. Either secondary centrosomes are formed at the two poles of the central spindle whereby the original centrosome goes to pieces, or, since the original centrosome is always near at hand, the two dark hemispherical bodies which appear on both sides of the central spindle may be formed by division of the original centrosome, and these two bodies later become differentiated into new centrosomes, one for each daughter nucleus. The whole nuclear and cell division in *Surirella calcarata* was completed in from five to five and one-half hours.—J. H. S.

ITEMS OF taxonomic interest are as follows: In their continuation of Welwitsch's African freshwater algæ, Messrs. W. West and G. S. West describe three new genera;[9] *Psephotaxus* (Ulotrichaceæ), *Temnogametum* (type of a new family of Conjugatæ, in which conjugation occurs only between specially abstricted cells), and *Pyxispora* (Zygnemaceæ). Bulletin 4 of the Division of Agrostology contains a revision of the genus Ixophorus by F. Lamson-Scribner; a list of the grasses collected by Dr. Palmer near Acapulco, Mexico, in 1894–5, among which is a new genus *Fourniera* (Zoysieæ), by the same author; some Mexican grasses collected by E. W. Nelson in 1894–5, by F. Lamson-Scribner and Jared G. Smith; some American Panicums in the Herbarium Berolinense and in the herbarium of Willdenow, by Theo. Holm; native and introduced species of Hordeum and Agropyron, with keys, by F. Lamson-Scribner and Jared G. Smith; and miscellaneous notes and descriptions of new species, among which *Chætochloa* Scribner is proposed as a new generic name for Setaria, which is untenable for several reasons, and neither Chamæraphis nor Ixophorus is available as both are well-defined genera and abundantly distinct. Bulletin 6 of the Division of Agrostology gives a full account of the grasses and forage plants of the Dakotas, by Thomas A. Williams. Mr. P. A. Rydberg, in continuation of his studies of Potentilla,[10] describes four new species. Miss Anna Mary Vail has published notes on Parosela[11] (Dalea), which include descriptions of three new species, besides the transfer of specific names. Dr. Charles Mohr has published notes on some undescribed and little known plants of the Alabama flora,[12] among which are new species of Sagittaria and Oldenlandia. Mr. Geo. V. Nash has described[13] new species of Erianthus, Paspalum, Panicum, Agrostis, and Danthonia. A new Prunus from Connecticut, *P. Gravesii*, is described by Mr. John K. Small,[14] and a new Crataegus from Virginia, *C. Vailiæ*, by Dr. N. L. Britton.[15] In the continuation of the account of Welwitsch's African fresh water algæ,[16] among the numerous new forms of Desmidiaceæ, W. West and G. S. West describe a new genus, *Ichthyocercus*. The February number of the *Bull. Torr. Bot. Club*[17] contains descriptions of numerous new fungi, chiefly from Alabama, by L. M. Underwood; a new Lechea from Maine, by E. P. Bicknell; a new violet of the Atlantic coast and a new geranium, by N. L.

[9] Jour Bot. **35**: 33–42. 1897.

[10] Bull. Torr. Bot. Club **24**: 1–13. *pls. 287, 288.* 1897.

[11] Bull. Torr. Bot. Club **24**: 14–18. 1897.

[12] Bull. Torr. Bot. Club **24**: 19–28. *pls. 289–291.* 1897.

[13] Bull. Torr. Bot. Club **24**: 37–44. 1897.

[14] Bull. Torr. Bot. Club **24**: 44. *pl. 292.* 1897.

[15] Bull. Torr. Bot. Club **24**: 53. 1897.

[16] Jour. Bot. **35**: 77–89. 1897.

[17] Bull. Torr. Bot. Club **24**: 81–86, 86–90, 92–93, 93–94. 1897.

Britton; and a new Ribes from Idaho, by A. A. Heller. Mr. F. V. Coville[18] has described a new Collomia from Oregon, and Mr. John B. Leiberg[19] a new Delphinium and a new Sambucus from the northwest coast. G. Hieronymus[20] has begun the publication of the spermatophytes of the Argentine Republic, Uruguay, Paraguay, Brazil, and Bolivia, the first paper including the Vernonieæ and Eupatorieæ. The great display of these tribes to the south may be judged by the fact that over 200 species are presented, almost 100 of which are new. The three great genera are Vernonia, with fifty-six species, twenty-five of which are new; Stevia, with forty-five species, twenty-seven of which are new; and Eupatorium, with seventy-five species, twenty-six of which are new.— J. M. C.

ABOUT THREE YEARS AGO the Hatch Experiment Station published a bulletin upon the effect of the electric current in promoting the growth of plants, which was somewhat adversely commented upon in this Journal.[21] The same station has now issued another bulletin dealing with the subject from another standpoint. The work was done by Asa S. Kinney,[22] under the supervision of Professor George E. Stone, and relates chiefly to acceleration of growth during germination. Very few of the attempts to study the action of electricity upon plant life have made any substantial contribution to our knowledge of the subject. The present paper, however, appears to show that beyond doubt a small alternating current of moderate frequency and fairly high voltage when applied for a short time has a stimulating effect upon growth.

The experiments were in three series. In the first series 200 seeds of a kind, after being soaked in water for twenty-four hours, were divided into lots of twenty-five seeds each, and exposed to the electric current at different voltages for two minutes, with exception of one lot kept for comparison. Seeds of white mustard, red clover, rape and barley were used. The source of the current was four Leclanché cells, acting upon a secondary induction coil through a primary coil and interrupter. The results are shown in the number of seeds germinating at intervals of 24, 48 and 72 hours, and the average length of the radicles at the close. A second trial was carried out in the same manner, but using two Samson no. 1 battery cells, and continuing the treatment five minutes instead of two. A third trial was made in all particulars like the first trial but omitting the barley, and continuing the observations to a fourth interval of ninety-six hours, and measuring both radicle and hypocotyl. For the three trials 2200 seeds were used.

[18] Proc. Biol. Soc. Wash. **11**: 35–37. 1897.

[19] Proc. Biol. Soc. Wash. **11**: 39–41. 1897.

[20] ENGLER's Bot. Jahrb. **22**: 672–798. 1897.

[21] **19**: 88. 1894.

[22] Electro-germination. Bull. Hatch Exper. Station, no. 43, 32 pp. Illust. 8vo. Amherst, January 1897.

The resulting data show a convincing uniformity. In all cases there was an increase in the rapidity of germination and elongation of the radicle and hypocotyl in the treated seeds, with a distinct optimum above and below which the treatment was less effective, although never injurious.

In the second series 100 seeds each of white mustard, rape and red clover were used in lots of twenty-five. The treatment was for two minutes. One lot received the current as in the first trial of the previous series using what had been shown to be the optimum voltage. The second lot was treated in the same manner except that the number of interruptions of the primary current was reduced from about 6000 for the two minutes to 10. The third lot received the direct current from the cells; and the fourth lot served for comparison, being untreated. Two trials were made, corresponding to the first and third trials of the previous series, 600 seeds in all being used.

The resulting data show a favorable effect from all three forms of treatment, there being small difference between them in hastening germination, but in growth of radicles and hypocotyls the alternating current of higher frequency giving best results.

The third series is not so fully reported as the others, but was equally satisfactory in results. It consisted in stimulating seedlings at regular intervals for some days, in order to see if beneficial effects would continue to be shown as the plants grew. The current was the same as in the first trial of the first series, and was passed through a funnel or flower pot of moist sand in which the seedlings were grown. By attaching the primary wires to a clock movement the current was set up for about thirty seconds at the beginning of each hour. In one trial seedlings of horse bean (Vicia Faba) were observed for two days, and in another trial seedlings of white lupine (Lupinus albus) were observed for fourteen days. Both trials gave increased growth.

These several experiments and their results are clearly and concisely reported, and in a form that makes the data valuable for study. The report is not accompanied, however, with any discussion of the physiological action of electrical stimuli, or of the philosophy of the mode of treatment adopted. These are very alluring topics, but must be passed over for the time being.—J. C. A.

THE EXPERIMENTS whose results are embodied in a late paper were begun on the influence of temperature upon the osmotic processes in living cells in 1892 by Professor Krabbe, but the manuscript was left unfinished at his death, and prepared for publication by Dr. Kolkwitz.[23]

All attempts to prove with living cells, as was done with his artificial cell by Pfeffer, and in theory by von t'Hoff, that the osmotic pressure is propor-

[23] KRABBE, G: Ueber den Einfluss der Temperatur auf die osmotische Processe lebender Zellen. Jahrb. f. wiss. Botanik **29**: 441.

tional to the absolute temperature, were unsuccessful, the turgor being too high at low temperatures. In investigating the influence of temperature on the rapidity of the osmotic movement of water more satisfactory results were obtained. It was found, for instance, that if cylinders of the pith of Sambucus 180.5^{mm} long were placed in a 24 per cent. cane sugar solution at 0 to 1°C., and at 20°C., the contraction in 2^{h} 15^{m} was to 176.5^{mm} in the former, to 147^{mm} in the latter; that is, at 20° more that eight times as much water had been given off as at zero, transverse contraction being neglected. Conversely, when pith was placed in distilled water at 4° and at 26°C., the elongation within 15^{m} was about four times as great in the latter as in the former. In experiments with roots (*Vicia Faba* and *Phaseolus multiflorus*) the difference was less, the ratio never exceeding 1 to 2.5 during the first five minutes, and decreasing with the duration of the experiment. The ratio of the amount of elongation of plasmolysed roots in distilled water at 4° and 26°C. was about 1 to 3 during the first ten minutes. Poiseuille's formula provides for an average increase in the viscosity of water of 0.034 for each degree C. above zero. Pfeffer's observations at 7.1°, 17.6°, and 32.5°C. suggest an increased rapidity of osmosis through copper-ferrocyanide membranes of 0.045 per degree, or from 1 to 1.9 with 20° increase. His own figures being considerably higher, Krabbe concludes that they must depend on the living nature of the protoplasm. At a low temperature, the condensation of the protoplasm makes it so resistent to the passage of water that if pith cylinders in ice water, whose elongation has ceased, be split, the halves become concave on the inner surface. In a certain sense the condition of the protoplasm here regulates the turgor without being pervious to anything but water.[24] Krabbe believes that at 24°C. the intermicellar openings are already large enough to permit some exosmosis of the cell content into pure water, but no figures are given in proof.

The increased inner friction of water when cooled, represented by Poiseuille's formula, may claim more or less of a share in the decreased rapidity of osmosis, as it is slightly or decidedly overshadowed by friction against the membrane. But the latter element is always present, and when 50 to 200 membranes obstruct the way it may well suffice to explain the difference of tensions at surface and interior of the pith cylinders. It is no more reasonable to expect different membranes to show like variation in this respect than to assume for all substances a common coefficient of expansion when heated. The resistance to filtration is an unknown[25] function of the diameter of the interstices. The finer these already are, the greater must be the effect of a given further decrease; so we should anticipate for protoplasm, impermeable to many substances, KNO_3 etc., which traverse the copper ferrocyanide membrane

[24] Cf. Pfeffer, Zur Kenntniss der Plasmahaut und der Vacuolen, etc. 302 [156].

[25] In capillary tubes of measurable size, the resistance varies with the fourth power of the radius; in the case in question the power is probably higher.

a considerably more marked response to changes of temperature than is displayed by the latter. This being so, it is unnecessary to refer the difference to the vitality of the protoplasm.

Essentially the same phenomenon described by Krabbe is that of bleeding, decreasing rapidly as it does with falling temperature, and usually ceasing some degrees above zero.

While in the life of the plant the protoplasm must permit the wandering of various food matters from cell to cell, and, therefore, be permeable to them under circumstances which we do not sufficiently understand, it is extremely doubtful if perfectly healthy cells ever permit exosmosis of anything except water when immersed at room temperatures. Determinations of turgor are ordinarily made at such temperatures, and though Krabbe does not carry his point so far, their accuracy would at least be shaken by the possibility of such a process. And as plants live and grow at such temperatures, what is to limit the filtration of the sap from the cells? That this does not occur so as to be appreciable by any test of plasmolysis, or measurement, unless by fine chemical reactions, needs no argument. That it does begin with injury to the protoplasm is a matter of common experience receiving critical attention from De Vries.[26]

Last year the writer had occasion to determine very carefully the turgor of leaves of several mosses, and of the roots of *Vicia Faba* and other phanerogams at temperatures from 0° to 37°C., and while the temperature appreciably affected the time required for plasmolysis, it had not the slightest discernible influence on the ultimate result. These experiments covered a wider range of temperature than Krabbe's. The conditions were different in that practically all the cells were in immediate contact with the plasmolysing solution. And while the results confirm Krabbe's conclusion that the combined resistance of many layers of protoplasm is responsible for the difference of tension in cold water between the axis and periphery of pith cylinders, and for their failure to plasmolyse completely at 0°C., they are unfavorable to the idea of the filtration from the healthy cell of any of its turgor-producing contents. Any such action was a stage of death.

Finally the statement that pith in cold water does not stretch beyond its limit of elasticity holds good according to Kolkwitz[27] only when the time of immersion does not exceed four to six hours.—E. B. COPELAND.

[26] Bot. Zeit. **42**: 289.

[27] Fünfstück's Beiträge zur wiss. Botanik, 1895.

NEWS.

THE ROYAL ACADEMY of Sciences of Berlin offers a prize of *M* 2000 for a memoir on the origin and characteristics of the varieties of grain during the last twenty years. The manuscript, which may be written in German Latin, French, English or Italian, must be sent to the Bureau of the Academy (Universitätsstrasse 8, Berlin NW., before Dec. 31, 1898, with name of the writer in sealed envelope. The work must be based upon special experiments and observations.

THE HOPI are one of those interesting tribes which remain as relics in the desert and cañon region of the southwest. Compelled to utilize everything organic that is available, in the paucity of animals they have made a surprisingly complete use of their scanty vegetation. Mr. Walton Hough has made a collection of the Hopi plants, which have been named by Dr. J. N. Rose and published, with their native names and uses, in the *American Anthropologist* for February. It is estimated that there are not over 150 indigenous species in the Hopi environment, northeastern Arizona, but Mr. Hough's collection reveals the fact that about 140 of these are used in agriculture and forage, arts, architecture, domestic life, dress and adornment, folk lore, food, medicine, and religion.

THE PROCLAMATION of President Cleveland setting apart thirteen new forest reserves, representing an area of more than twenty-one million acres is noteworthy. This increases the total reserve forest land in the West to thirty-nine million acres. We quote from *Garden and Forest* in stating that the new reserves include all the central portion of the Black Hills of South Dakota, the Big Horn mountain range in Wyoming, the Jackson lake country south of the National Park in Wyoming, all the Rocky mountains of northern Montana, a valuable forest region in northern Idaho, the principal part of the Bitter Root mountain region in Montana and Idaho, the Cascade mountains of northern and southern Washington, the Sierra summits of California north of the Yosemite National Park, the San Jacinto mountains in southern California, and the Uintah mountains in northern Utah. The selection of these forest lands was made by the commission appointed by the National Academy of Sciences. Since the proclamation strenuous objections have been made by interested inhabitants, so that it is difficult to tell whether it will become operative throughout all the areas indicated.